Project Finance Advisory Ltd.

MEMORANDUM

Date: February 27, 2017

To: Mr. Boris Lipkin
Deputy Director of Business
Analytics and Commercial Implementation
California High Speed Rail Authority
700 L Street
Sacramento, CA 95814

Re: Operations and Maintenance Costs for Valley to Valley Line and PCEP Scenario of the California High-Speed Rail System, and Whether Each Scenario Will Require an Operating Subsidy

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1. EXECUTIVE SUMMARY

In December of 2015, Project Finance Advisory Limited ("PFAL") was commissioned by the California High-Speed Rail Authority ("Authority") to provide an independent review of the detailed funding plans for the California High-Speed Rail System ("System"). On December 16, 2016, the Authority directed PFAL and their subconsultants, First Class Partnerships Limited ("FCP") and Anrab and Associates ("Anrab"), to complete work under Contract HSR14-65 Task Order 6 to review the Operations and Maintenance ("O&M") Cost Model ("Model") so as to:

- Review the Model's construction, assumptions, outputs and validation to form an opinion as to the reasonableness of the Model's forecasted costs of operating and maintaining the defined service; and
- Determine whether or not the planned passenger service to be provided by the Authority (or pursuant to its authority), will require an operating subsidy within the definitions set out in Proposition 1A for the following two scenarios:
    - **Valley to Valley Line:** defined in the 2016 Business Plan as Poplar Avenue to San Jose; and
    - **PCEP Scenario:** defined as Poplar Avenue to San Francisco including Valley to Valley Line and the Peninsula Corridor Electrification Project ("PCEP"), but no other improvements to the Peninsula Corridor[1].

The opinions and conclusions regarding whether or not the Authority's planned passenger service will require an operating subsidy utilizes the information presented in PFAL's Ridership and Revenue memo[2] performed under HSR14-65 Task Order 2 by PFAL and FCP (provided for convenience in Appendix B) and the O&M analysis described in Section 2 and 3 of this Memo.

This work undertaken in this Task Order 6 is independent from the work completed in Task Orders 3 and 4.

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[1] The PCEP Scenario was derived by the Authority and reviewed at the request of the Authority, but not included in the Authority's 2016 Business Plan.

[2] PFAL's Ridership and Revenue Memo dated February 13, 2017 included in Appendix B of this Memo is identical to the Ridership and Revenue Memo dated December 5, 2016 expect for the removal of "Draft" from the subject line and the addition of an industry standard disclaimer.

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Disclaimer

Project Finance Advisory Limited ("PFAL") and its subconsultants have performed an independent review of the operations and maintenance costs for the Valley to Valley Line and PCEP Scenario as directed by the California High-Speed Rail Authority ("Authority") and as described in PFAL's executed Task Order 6 with the Authority dated December 16, 2016. This independent review of the operations and maintenance costs was performed using documents and information provided by the Authority (listed in the body of this Memo) and developed using currently accepted professional practices and procedures. PFAL, at the Authority's direction, has relied upon the accuracy and completeness of the documents and information provided by the Authority. While Authority assumptions relevant to PFAL's analysis were reviewed for reasonableness, the accuracy and completeness of the documents and information provided by the Authority and other publicly available material reviewed by PFAL in connection with this Memo were not independently verified by PFAL (except as otherwise explicitly described in this Memo), and PFAL does not assume responsibility for verifying such material.

PFAL's opinions regarding the necessity of an operating subsidy as provided in this Memo are made in reliance upon the assumptions contained within the operations and maintenance cost review as well as the assumptions contained in the Ridership and Revenue memo (previously produced by PFAL) included as Appendix B to this Memo.

This Memo does not serve as an accounting audit. Furthermore, this Memo should not be relied upon for any financing or investment decision. It is possible that there are other elements of risk associated with the Authority's Operations and Maintenance Cost Model and Ridership and Revenue Model beyond those presented. Any financial estimates, analysis or other conclusions in this Memo represent PFAL's professional opinion as to the general expectancy concerning events as of the evaluation date and are based solely upon the information provided by the Authority and PFAL's analysis described in this Memo. However, the accuracy of any financial estimate, analysis or other information set forth in this Memo is dependent upon the occurrence of future events, which cannot be assured. Additionally, these estimates and analyses rely upon the assumptions contained therein, the accuracy of which remains subject to validation, further refinement and the occurrence of uncertain future events. Estimates should not be construed as statements of fact. There may be differences between the projected and actual results because events and circumstances may not occur as expected.

The information and conclusions presented in this Memo should be considered as a whole. Selecting portions of any individual conclusion without considering the analysis set forth in this Memo as a whole may promote a misleading or incomplete view of the findings and methodologies used to obtain these findings.

1.1 Findings

After conducting both a high-level "top-down" review (see Section 2.3.2) of the Authority's documentation used to support the development of the Authority's O&M Cost Model and a "bottom-up" review (see Section 2.3.3) of certain elements of the Authority's O&M model documentation, the PFAL and FCP team is of the view that:

- On the O&M costing:
  - the assumptions documented in the Operations and Maintenance Cost Model documentation 2016 Business Plan: Technical Supporting Document do form the basis for the O&M cost estimates;
  - the assumptions behind the cost level estimate and the associated contingency level are generally reasonable - though PFAL and FCP identified some adjustments which are explained in this Memo;
  - those adjustments that PFAL and FCP were able to quantify have a negative impact in the order of $22 million per annum following service and revenue ramp up ("Steady State" revenue), which

  - is approaching 8% of the cost base that the Authority has assumed for the Valley to Valley service; and
  - although four potential upside adjustments were identified, the value of three of these could not reasonably be estimated (based on currently-knowable facts) so were not included in our cost and subsidy calculations. It was outside the scope of this review to optimize the Authority's planned operating program and assumptions.

- On the subsidy requirement:
  - we conclude that it is likely the Valley to Valley Line can operate without subsidy after an initial start-up period based on central case assumptions (described below);
  - as we have also assumed additional costs, but no additional revenues, for the PCEP Scenario, we conclude also that it is likely that this service too can be operated without subsidy after the initial start-up period based on central case assumptions;
  - the Authority's modelled central case, as defined by the Authority in the 2016 Business Plan, for the Valley to Valley Line O&M cost is substantially lower than the Authority's modelled central case for the Valley to Valley Line revenue in each year of operation from 2025 to 2039, apart from 2025 which is the first year of operation. O&M costs under these conditions are 55% - 60% of forecast revenue during the post 2032 steady-state years;
  - when evaluated against the additional adjustments PFAL and FCP identified, as noted above, the Valley to Valley line can be operated on an ongoing basis without subsidy based on central case assumptions, as forecast revenue will exceed the adjusted modelled O&M costs from the third year of operation;
  - the addition of services to San Francisco under the PCEP Scenario is modelled by the Authority to increase O&M costs by $12 million per year, which does not lead to a requirement for a subsidy in the Valley to Valley Line central revenue case (except in 2025), even under the conservative approach where no additional revenue is assumed for the extension to San Francisco from San Jose. With the incremental O&M costs for service to San Francisco plus the adjustments PFAL and FCP identified for the Valley to Valley Line - but no assumed additional revenue - the O&M cost is about 65% of the revenue at Steady State, leaving a surplus of nearly $165 million at the start of full ramp up rising to a surplus of just over $200 million per annum in the period reviewed;
  - in the review of revenue, FCP and PFAL concluded there was a 90% probability that revenues would be at least 58% of the Authority's forecast. If in fact ridership is only 58% of projected levels, there would be other cost saving opportunities (e.g. some services might be curtailed and on-board crew might be reduced). When evaluating the Valley to Valley line, PFAL adjusted O&M costs against the 58% of revenue scenario, and operations are found to have a surplus starting in year 2038. These changes, and the other un-quantified cost savings we have identified, likely could allow the service to operate without subsidy even in this very pessimistic revenue scenario; and
  - there also may be various additional ancillary revenue opportunities, most notably from car parking, and also from on-board food and beverage sales. The Authority's revenue forecasts assumed that ancillary revenues are only 1% of fare revenues, which is very cautious.

1.2 Key assumptions

The operating subsidy requirement is defined according to the applicable regulations and definitions provided by the Authority in which:

- "Revenue" includes: fare box revenue (income from ticket sales) and Ancillary revenue, which includes income the Authority may receive from sources related to the everyday business operations of the high-speed rail, including but not limited to on-board sales (e.g., sales of foods or sundries), station-related revenues, advertising, and revenues from leases of excess or non-operating right-of-way parcels or areas, as well as areas above or below operating rights-of-way or of portions of property not currently being used as operating rights-of-way. Ancillary income does not include unexpected or "one time" events.

- "Operating and maintenance cost" is defined as: the cost of running the trains and maintaining the infrastructure and rolling stock in a state of good repair. By definition, this category does not include capital asset renewal (also called "lifecycle") costs, which is the cost of replacing or refurbishing worn out components at the end of their useful life.
- "The planned passenger service to be provided by the Authority, or pursuant to its authority, will not require an operating subsidy" means: The consultant can indicate that, within a reasonable period of time after commencement of high-speed train operations on the segment or section evaluated, project revenues will reach an operating break-even point at which aggregate revenues up to that point in time equal Authority-borne operating and maintenance costs to that point in time and such revenues will continue to equal or exceed operating and maintenance costs thereafter.

Our analysis and conclusions rely on the underlying assumption that the project, as a whole, is delivered in accordance with the assumptions in the 2016 Business Plan. Of particular note to the conclusions of this review is the assumption that all start-up costs are fully covered outside of the O&M model as the O&M Cost model is based on the premise that a fully operational railway is available from day 1 of service commencement.[3]

There are a number of outstanding procurements that could change the findings and assumptions of this Memo. These include the procurement of an early operator (currently under procurement), long-term operator, and rolling stock. This review is based on the preliminary assumptions provided by the Authority in regards to the early operator and rolling stock procurement, which are still under discussion and development by the Authority's staff and Board[4].

Consistent with Task Order 6, the main analysis herein focuses on the Valley to Valley scenario, and the additional section of the PCEP Scenario (San Jose to San Francisco section) is treated as an increment. This Memo and the Ridership and Revenue memo in Appendix B both assume the San Francisco Peninsula Corridor is electrified. If the San Francisco Peninsula Corridor is not electrified or if planned works are significantly delayed past Authority's planned passenger service date, the findings of this Memo and the Ridership and Revenue memo in Appendix B may no longer be valid. While the impact to the PCEP Scenario could be substantial, the impact to the Valley to Valley Line may be minor; determining the magnitude of the impacts would require additional review.

For our review of the O&M costs and of the sensitivities, FCP built a "synthesized" model to test the accuracy of the implementation of the stated O&M assumptions. This "synthesized" model did not, nor was used, to develop independent or separate O&M cost forecasts. Its only purpose was to provide a tool to review the reasonableness of the Authority's Model. The "synthesized" model relied entirely on the Authority's inputs and information.

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[3] PFAL's review is not an audit and does not make any opinions on the accounting principles or practices assumed by the Authority as it pertains to the treatment of capitalization in its documentation.

[4] The Authority's February 14, 2017 Board Meeting requested additional clarification from the Authority's staff explaining their approach to an operator before issuing an RFP for the early operator.

We understand the Authority intends to proceed with the domestic trainset manufacturing and assembly process that requires full compliance with Buy America requirements[5] which will adopt service-proven designs with a minimum of 5 years in-service history that will be compliant with the new FRA Tier III rulemaking.

The Authority intends to procure two prototype trainsets which will be used to support trainset testing, core system commissioning, trainset commissioning, latent defect discovery and O&M training prior to revenue service commencement. The cost associated with the testing and commissioning is accounted for as a capital cost under the Authority's Business Plan and not included in the Authority's O&M Cost Model. The Buy America provisions primarily impact the capital costs and delivery schedule prior to revenue-service commencement and lifecycle costs of the system, which we understand the Authority has considered and does not fall within the scope of this review. The Authority has stated the Buy America provisions do not apply or impact any aspect of in-service operations, maintenance or spare-part procurement. Therefore, the Authority has determined that there is no uncertainty due to the Buy America requirements that would impact the Authority's O&M Cost Model or assumptions which would require mitigation or a contingency allowance beyond their current estimates.

Independent verification of the Authority's interpretation of Buy America rules does not fall within the scope of this review, and we recognize that nothing prohibits the Authority or future bidders/operators from seeking Buy America waivers in the future if they are deemed to be required.

1.3 Opportunities and Observations

In addition to the O&M cost adjustments noted above under Section 1.1, listed in Table 1 and further detailed in Section 4 (i.e., adjustments where we believed costs will be higher than the Authority's projected O&M costs), we identified areas where costs could potentially be reduced from the figures the Authority has projected. These include:

- Staff optimization – We expect an operator to obtain higher than assumed productive working time from staff, once the service pattern and standards and crew depot locations are known. This potential gain will be hard to quantify until the early operator is in place and the service standard and train crew depot locations are known.
- Cost of shared facilities - The model includes the full cost of shared facilities. While this represents a conservative cost assumption, we would expect an equitable cost sharing arrangement to be put in place which would reduce the currently modeled O&M cost to the Authority. We have not attempted to predict the result of such a negotiation as this is outside our work scope.
- Removal of Terminal Control Facilities from the model – In line with statements in the Authority's 2016 O&M Model Cost Model Documentation Report, we agree that the final design of the system and developments in operating practices may remove the need for these facilities. The Authority stated to us its view that the removal of Terminal Control Facilities would reduce annual costs by $4.3 million, a number we do not dispute. Accordingly, we included this cost reduction in our subsidy calculations (see Table 11), although we rounded the number to $4 million in our calculations.

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[5] The Authority withdrew its September 16, 2016 requests for the following two waivers from the Federal Railroad Administration's ("FRA") Buy America Requirements: a waiver to permit the manufacturer of the Authority's new Tier III High-Speed Trains ("Authority's Trains") to purchase and incorporate into the Authority's Trainsets certain components that are not manufactured in the United States. Specifically, these components were Car Body Shell: (1) car body shells (shell structure/frame-end, floor, roof, side); (2) integrated cab/CEM structure; (3) vehicle paintwork; and Brake System: (4) brake control unit; (5) disc brake equipment; (6) tread brake equipment/tread cleaners; (7) brake valves and (8) parking brake units; and a waiver to the manufacture and assembly of complete HSR trainset bogies (also known as trucks).

- Greater Efficiency from Train and Infrastructure Inspection Technology - Continued improvements in train inspection technology will increase the productivity of depot staff and result in financial savings. In the scenarios under review, the size of the train fleet is very small and without the critical mass to generate significant savings. Therefore, in the context of this review, we believe the potential cost reduction to be gained low. However, we do believe that automating routine inspection of the infrastructure through train-borne and fixed monitoring equipment has the potential to materially reduce the currently modelled Maintenance of Infrastructure ("MOI") costs, though by an amount difficult to specifically quantify and forecast with currently-knowable information. The Authority has stated that the use of this technology and a change in the currently mandated inspection regime is under discussion with the Federal Railway Administration ("FRA").

As noted above, we found several areas of the modelled O&M costs that appeared to differ from PFAL and FCP's benchmark data and experience– i.e., areas where we believe the Authority's estimates may be understated. These are set out in Table 1 and further detailed in Section 4.

Table 1: PFAL O&M Adjustments

O&M Cost	Annual cost in full ramp-up ($m)
Overtime Payments[6]	$9.40
Retail System	$6.00
Rail Maintenance Vehicle Costs	$1.59
General Admin Establishment	$2.96
Ongoing training – *of which*	$1.57
- Drivers & Conductors	*$0.41*
- Other staff	*$1.11*
- Newly recruited Drivers	*$0.07*
Cleaning Materials	$1.02
Specialist IT Systems	$0.20
Train Maintenance Water Consumption	$0.08
Total PFAL adjustment cost	**$22.84**

In summary, we found areas where the Authority's O&M model likely understates O&M costs and other areas where the model likely overstates O&M costs. In developing our independent analysis of O&M costs, we primarily made quantitative adjustments in areas where we believe the model likely understates costs, for two reasons. First, three of the four overstated costs areas are difficult to meaningfully quantify at this time. Second, we cannot, as a matter of good practice, assume potential efficiencies or cost reductions will materialize. We appreciate the Authority views this as a conservative approach.

[6] The Authority believes that staff optimization (discussed above) would likely result in a lower staff normal time cost. Therefore, as the overtime figure here is calculated as a percentage of normal time there will be a consequent reduction in the modelled overtime cost.

1.4 Memo Contents

The remainder of this Memo covers:

- Review methodology (Section 2)
- The main findings of the top down and bottom up O&M cost analysis (Section 3)
- Possible adjustments to the O&M Costs (Section 4)
- Scenario analysis for the subsidy question for the Valley to Valley service (Section 5)
- Scenario analysis for the subsidy question for the PCEP service (Section 6)Conclusions (Section 7)
- A Technical Appendix that sets out the review comments on each category of cost (Appendix A)
- A Ridership and Revenue Appendix from PFAL's review of the Authority's ridership and revenue model (Appendix B)

2. REVIEW METHODOLOGY

2.1 Relevant Material

Seven key documents were reviewed and relied upon for the analysis under this Memo. Those key documents are listed in Table 2.

Table 2: Key Documents

Document Description	Document Name
Demand Model	Ridership and Revenue Forecasting 2016 Business Plan Technical Supporting Document
Valley to Valley Timetable	Example Timetable Valley to Valley (December 31, 2016)
Operations Model Document – 2016 Business Plan	Service Planning Methodology 2016 Business Plan Technical Supporting Document
O&M Cost model Document – 2016 Business Plan	Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document
Authority's 2016 Business Plan	2016 Business Plan: Connecting and Transforming California
PFAL Requested O&M Cost Results	O&M Results (December 2016)
Cash Flow memo	Overview of Valley to Valley Line Cash Flow Scenarios

Each of these documents was provided by the Authority and, where necessary, further detail was provided by the Authority in their answers to PFAL's clarification questions.

2.2 O&M Review Task

To verify that the Valley to Valley Line and PCEP Scenario (Poplar Ave. to San Francisco) can operate without subsidy, PFAL and FCP first set out to validate and/or challenge the provided O&M costs built up from:

1. An assumed service specification (the same as used in the demand forecasting which the PFAL/FCP team has already verified)
2. A set of assumptions for resourcing the operation (staffing levels, fleet size, maintenance facilities, materials, utilities, etc.)
3. A set of unit cost assumptions for costing the operating resources
4. An assumed ramping up from partial to full operation over the first eight years of operation

The task was therefore to review these four sets of assumptions with respect to whether:

1. They are 'necessary and sufficient' (i.e. they cover all areas of O&M required for a high-speed railway, and do not include any areas that are not required)
2. The values used are appropriate for a high-speed railway in California

The methodology employed by the team to complete this task was as follows:

1. Review the inputs and assumptions from which the O&M costs were derived
2. Identify the key documents that describe the cost derivation process, and the assumptions, processes, and results that can be found in each document
3. Perform a 'top-down' review of the cost derivation process by working backwards through the document chain, verifying that the results were consistent throughout, and observing where costs were consistent with expected results based on our experience
4. Undertake a 'bottom up' verification of the cost derivation process to the extent that time and data availability allowed

2.3 Review Approach

2.3.1 THE O&M COST DERIVATION PROCESS

Figure 1 shows PFAL and FCP's understanding of the O&M cost derivation process used by the Authority, with references in blue to the key documents described below.

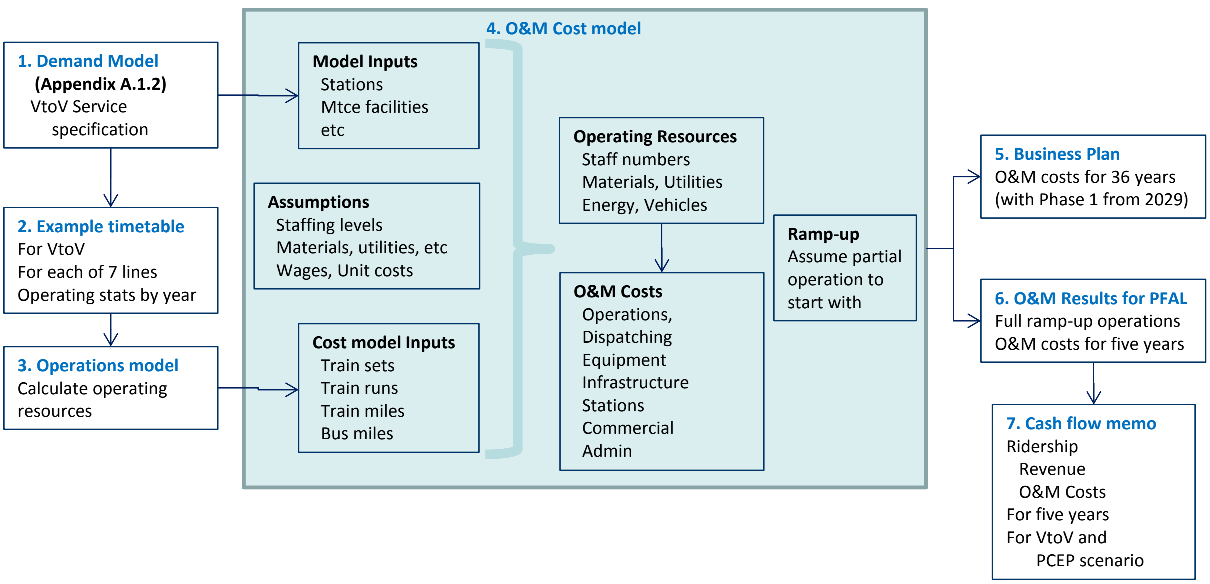


Figure 1: The process for deriving O&M costs from a service specification

2.3.2 THE TOP-DOWN REVIEW PROCESS

The objective of the top-down review was to trace the flow of information through the various documents and verify whether or not each of the following conditions held true:

- The costs presented in 7: Cash flows are consistent with those in 5: Business Plan and 6: O&M Results
- The costs presented in 5: Business Plan are consistent with the operating resources in 6: O&M Results and the unit costs in 4: O&M Cost model (sections 3 to 14)
- The calculated operating resources in 6: O&M cost results(slide 3, top half) are consistent with the model inputs in 6: O&M cost results(slide 3, bottom half) and the resourcing assumptions in 4: O&M Cost model (sections 3 to 14)
- The model inputs in 6: O&M cost results are consistent with the methodology in 3: Operations model and the timetable in 2: Valley to Valley timetable

- The infrastructure inputs (Stations, maintenance facilities, etc.) in 6: O&M cost results (slide 3) are consistent with the methodology in 3: Operations model and the timetable in 2: Valley to Valley timetable
- The timetable in 2: Valley to Valley timetable is consistent with the service specification in 1: Demand model (Appendix A.1.2)

2.3.3 THE BOTTOM-UP REVIEW PROCESS

The 'bottom-up' review focused on the Cost Model section of the diagram in Figure 1 above, with the objective of validating the Authority's O&M cost estimates by verifying that:

- The O&M cost estimates are consistent with the documented assumptions
- The documented assumptions are reasonable and appropriate in terms of cost drivers and values used

The first objective was addressed by:

- Constructing a 'synthesized' model to replicate the cost derivation process described in the cost model documentation that supports the Authority's O&M cost model
- Verifying whether the results produced by the synthesized model are consistent with those produced by the Authority's O&M cost model
- Using the synthesized model to assess the cost impacts of various potential adjustments to these assumptions

The second objective was addressed by constructively challenging the resourcing and unit cost assumptions described above, focusing on questions such as:

- Are the resource categories assumed necessary and sufficient for the operation of the Valley to Valley high-speed railway?
- For resources assumed to be driven by the level of operations, are the assumed drivers appropriate?
- Where values of certain resources have been assumed, are these values reasonable?
- Are the unit costs associated with these resources reasonable? (or at least have they been reasonably derived from the stated sources?)
- Are the allowances for General Administration and Contingency reasonable?

The first stage of the constructive challenge involved establishing a list of all of the costs involved in setting up and operating a high-speed railway, based on the team's extensive international experience and assessing whether each cost area is:

- Included in the Authority's O&M cost model
- Included in the Authority's lifecycle cost model
- Not found in either model

The costs included in the O&M cost model were benchmarked against international comparator railways where possible using key indicators and ratios.

3. MAIN FINDINGS OF THE O&M COST ANALYSIS

3.1 Results of Top-down review

There were several issues to consider in verifying the consistency between documents:

- Some costs and revenues were presented in Year of Expenditure dollars ($YOE) and some in 2015 dollars ($2015)
- Most documents only presented Valley to Valley costs and revenues up to 2028, after which figures for Phase 1 (San Francisco Bay to Los Angeles Basin) were presented. Phase 1 is outside of the scope of PFAL and FCP's review under this task order. The Authority provided the necessary information to evaluate the Valley to Valley and PCEP scenarios beyond 2028 through a separate forecast for purposes of this review.
- Operations were assumed to ramp up over eight years, so the first year of full ramp up was 2033
- Revenue was assumed to ramp up over four years, reaching 100% of Steady State in 2029, i.e. in advance of the full service ramp up.

After accounting for each of these issues, the top-down review established consistency between the costs and revenues in all the key documents depicted in Figure 1 above. The verification of the workings of the O&M Cost model was carried out through a bottom-up review which is described later in this Memo.

3.1.1 DEMAND MODEL

The Demand model document was reviewed only to confirm that the service specification is consistent with the service plan assumed in generating the ridership and revenue forecasts. Figure 2 shows the service specifications reviewed in the demand model.

Train
6 Peak Hours

Pattern #	10
Frequency	30
Run times from start in minutes	
San Jose	**0**
Gilroy	18
Fresno	62
Visalia	83
North Shafter	**118**
# of trains	12

Train
10 Off-Peak Hours

Pattern #	10
Frequency	60
Run times from start in minutes	
San Jose	**0**
Gilroy	18
Fresno	62
Visalia	83
North Shafter	**118**
# of trains	10

Figure 2: Service Specification (source: Demand Model Appendix A1.2)

3.1.2 VALLEY TO VALLEY TIMETABLE

The example Valley to Valley timetable presented in Example Timetable Valley to Valley (December 31, 2016) provides the basis for the operating resources but the Authority has stated this information is considered indicative.

The team verified that this timetable can actually be operated and provides the level of service specified in the Demand model and the O&M Cost model, O&M Results (December 2016), slide 3.

3.1.3 OPERATIONS MODEL

The method of calculation of the operating resources from the timetable is presented in Service Planning Methodology 2016 Business Plan Technical Supporting Document.

The team confirmed that the assumptions used are reasonable for a high-speed railway in California and verified that applying the specified method of calculation produces the (full ramp-up year) service statistics (for input to the O&M Costing model) as presented in O&M Results (December 2016), slide 3.

3.1.4 COST MODEL

The cost modelling methodology is described in detail in Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document.

No actual results are shown, but the file O&M Results (December 2016) provides some of the inputs and model results for the Valley to Valley and PCEP scenarios.

The process by which the team verified that the O&M Cost model's results are consistent with the documented assumptions described in detail under the applicable headings in Section 3 of this Memo.

3.1.5 BUSINESS PLAN

The O&M costs for future years are presented in Exhibits 7-11 to 7-16 2016 Business Plan.

The team verified that these costs are consistent with the costs for Valley to Valley shown in O&M Results (December 2016).

Whether or not these costs are consistent with the methodology and assumptions in Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document, was left as a question for the bottom up review.

3.1.6 O&M RESULTS

The Authority provided O&M results specific to this review. The file O&M Results (December 2016) presents (in slide 3, bottom line) the (full ramp-up year) O&M costs for Valley to Valley, and (in slide 6) the breakdown by category of the O&M costs for the first four years of Valley to Valley with Phase 1 being introduced in 2029.

Whether or not these costs are consistent with the methodology and assumptions in Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document, was left as a question for the bottom up review.

The team established that the total O&M costs for the years 2025 to 2029 as presented in O&M Results (December 2016) (slide 6) are consistent with the costs presented in 2016 Business Plan (Exhibit 7.11 – Medium cost estimate), but both sets of costs are based on the introduction of Phase 1 in 2029, and cannot be used to validate the Valley to Valley only or PCEP scenarios under this task order for the period 2025 to 2029.

3.1.7 CASH FLOW MEMO

Ridership, Revenue, and O&M Costs (in YOE$, for five years, for Valley to Valley and the PCEP scenario) are presented in Overview of Valley to Valley Line Cash Flow Scenarios.

The team verified that these costs are consistent with the 2016 Business Plan and the O&M Results – for PFAL, but this is the only one of the key documents in which the 2029 costs represent the Valley to Valley-only scenario (as distinct from 2029 being the first year of Phase 1).

3.1.8 SUMMARY OF TOP-DOWN REVIEW FINDINGS

Having established that all the key documents are consistent with each other after allowing for the differences in representation, the top-down review concluded that the resources and costs associated with the first fully ramped up year (2033) are 1102 employees and an O&M cost of $295 million per annum as shown in Figure 3 which is taken from the O&M Results (December 2016), slide 3, and that these are consistent with the annual O&M costs by category that are discussed in Section 5.

Key O&M Assumptions
(all 2015 $, based on full ramp-up year projections)

	SJ-N. of BFD (2016 BP)	Peninsula Corridor Electrification Project (PCEP) SF-N. of BFD* (No Millbrae, AE penalties)
Total Operations Personnel	194	194
Dispatching Personnel	80	80
MOE Personnel	311	311
MOI Personnel	229	229
Station, Train, Cleaning Personnel	198	238
General and Admin Personnel	90	93
Total Employees	**1,102**	**1,145**
Trainsets	13	16
Access/Egress Adjustments	None	Yes*
Stations	5	6
Maintenance Facilities	1 HMF, 1 Level 3, 2 MOI	1 HMF, 1 Level 3, 2 MOI
Trainset Runs (Daily)	44	44
Bus Revenue Miles (Annual)**	11,001,100	11,001,100
Trainset Miles (Annual)	4,531,522	5,156,687
Marketing / Call Center	Yes	Yes
Total O&M ($M)	**~295**	**~308**

Figure 3: Authority O&M Assumptions (source: O&M Results (December 2016))

The next step was to use the bottom up analysis to verify whether or not these resources and costs are consistent with the assumptions in the Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document.

3.2 Bottom-up Analysis

The bottom-up analysis focused on the Inputs, Assumptions, Calculations and Outputs of the Authority's O&M Cost model as shown in blue in Figure 1 in Section 2.3.1.

Sections 3.2.1 to 3.2.6 of this Memo describe the six components of the costing methodology as applied to the Valley to Valley railway and what was reviewed within each component.

3.2.1 MODEL INPUTS

Certain elements of the Authority's O&M Cost model inputs are taken directly from the service specification (e.g. numbers of stations, maintenance of equipment facilities, maintenance of infrastructure facilities, daily trains run). These are shown in slide 3 of O&M Results (December 2016).

The team verified that the specified (12 + 1 spare) trainsets, 5 stations, 2 Maintenance of Equipment ("MOE") facilities, 2 MOI facilities and 5 stations are necessary and sufficient for the operation of 44 one-way train runs per day on the 250 mile-long Valley to Valley Line.

3.2.2 ASSUMPTIONS

The review of the cost model documentation established that the Operations and Maintenance Cost Model Documentation 2016 Business Plan Technical Supporting Document provides assumptions regarding:

- The resources (personnel, materials, equipment, etc.) required to operate and maintain a high-speed railway in California
- How the levels of such resources are driven by the level of operations (e.g. 1 return trip per crew shift)
- The costs and/or unit costs of such resources

The Authority's O&M Cost Model documentation is well written and explains in detail a set of generic assumptions and specific assumptions under each of the following headings:

1. Operations
2. Dispatching
3. Maintenance of Equipment
4. Maintenance of Infrastructure
5. Stations Operations and Stations and Train cleaning
6. Police and Security
7. Commercial
8. General Administration
9. Insurance
10. Contingency (Allocated and Unallocated)

The review established that these headings cover the necessary top-level cost areas for the running of a high-speed railway. We also found that within these cost headings, some necessary items had not been included in the O&M Cost model and some of the assumptions required revision.

Note that there are no costs associated with on-board food and beverage sales. This is because the Authority has assumed, in its revenue projections, that no such service would be provided. We agree that this is a conservative assumption. Very likely a commercial train operator would offer these services. As there are assumed to be 4 customer-facing staff on every train, very likely such a service could generate additional operating margins.

3.2.3 O&M COST MODEL INPUTS

The Authority's O&M Cost Model inputs related to the level of operations (e.g. trainset miles, bus revenue miles, number of trains turning at each station) are generated by the Operations model described in Service Planning Methodology 2016 Business Plan Technical Supporting Document. These are shown in slide 3 of O&M Results (December 2016).

The review verified that applying the service plan methodology in Service Planning Methodology 2016 Business Plan Technical Supporting Document to the timetable in Example Timetable Valley to Valley (December 31, 2016) did indeed generate the cost model inputs of 44 daily trainset runs and 4.5 million trainset miles per year.

3.2.4 OPERATING RESOURCES

Using the documented resource assumptions, the team built a 'synthesized' model to verify Operating Resources for each of the cost categories listed above. PFAL and FCP's synthesized model did not develop independent or separate O&M cost forecasts. Its only purpose was to verify the Authority's O&M Cost model and relied on the Authority's inputs and information.

The primary resource in most categories is labor and the synthesized model used the documented staffing assumptions to first generate the number of posts to be filled within each staffing category, then applied the appropriate 'Availability Factors' to generate the required numbers of full time equivalents ("FTEs"). Police, and security personnel were transferred into MOE, MOI, and Stations, and Yard-based Train cleaning personnel were transferred into MOE.

Table 3: Valley to Valley Staff Numbers Presented by the Authority as Cost Model Outputs

O&M Cost Category	Original Model Outputs	Adjustment	Adjusted outputs
Total Operations Personnel	194	22	216
Dispatching Personnel	80		80
MOE Personnel	311		311
MOI Personnel	229	31	260
Station, Train, Cleaning Personnel	198		198
General and Admin Personnel	90	4	94
Total Employees	**1,102**		**1,159**

The review was able to verify that the staff numbers in each category provided by the Authority (with Protect Crews and MOI Basic Facility day shift staff added to the staff numbers shown in slide 3 of O&M Results (December 2016) were indeed consistent with the documented assumptions.

The synthesized model also used the Authority's O&M Cost model inputs and assumptions to generate non-employee related resources such as: materials, vehicles, utilities, amount of energy consumed, uniforms, tools, office supplies, cell phones, and equipment; but the Authority did not provide resource values against which to verify these results.

3.2.5 O&M COSTS

By comparison of the Authority's O&M Cost model and the synthesized cost model, the team was able to verify that the O&M costs presented by the Authority are indeed consistent with applying the assumptions of wages and other unit costs to the operating resources, both in terms of total cost and the breakdown by category and by Labor and Other.

The 2016 Business Plan and O&M Results (December 2016) document both included assumptions related to the introduction of the Phase 1 system. Since this analysis was focused only on the Valley to Valley Line and the PCEP scenario (and makes no assumptions for Phase 1) in order to have forecasts that are only for these segments, the

Authority suggested a $6.5 million adjustment to the total cost of $295.4 million to allow for costs related to Protect crews and MOI Basic Facility day gangs that would become necessary in this scenario over time.

In Table 4, the O&M costs and labor percentages and the subsequent labor adjustment were provided by the Authority. Applying the labor component to the breakdown by category and then adding in the subsequent labor adjustment results in the adjusted O&M costs shown in yellow which provide the basis for the ensuing analysis. The figure $301.9 million is the Steady State cost for Valley to Valley for 2033 shown in the table in section 5.2.

Table 4: Valley to Valley O&M Costs by Category and Labor Percentage

O&M Category	Provided by the Authority		Derived		Provided by the Authority	Adjusted O&M Costs		
	O&M cost ($m)	Labor Component (%)	Labor Cost ($m)	Other ($m)	Labor Adjustment ($m)	Labor ($m)	Other ($m)	Total ($m)
Operations	41.1	59%	24.2	16.9	2.2	26.4	16.9	43.3
Dispatching	12.8	99%	12.7	0.1		12.7	0.1	12.8
MOE (inc Security, Train cleaning)	47.9	72%	34.5	13.4		34.5	13.4	47.9
MOI	53.5	52%	27.8	25.7	3.0	30.8	25.7	56.5
Stations (inc Security, Train cleaning)	21.8	90%	19.6	2.2		19.6	2.2	21.8
Commercial (inc Bus costs)	65.3		0.0	65.3		0.0	65.3	65.3
General Administration	15.1	93%	14.0	1.1	1.3	15.3	1.1	16.4
Insurance	26.2		0.0	26.2		0.0	26.2	26.2
Unallocated Contingency	11.7		0.0	11.7		0.0	11.7	11.7
Total	**295.4**	**45%**	**132.9**	**162.5**	**6.5**	**139.4**	**162.5**	**301.9**

At this point, the review concluded that the first year of full ramp-up operations (or Steady State) for the Valley to Valley railway, the O&M costs presented by the Authority are consistent with their own assumptions at the level of Labor/Other within the ten cost categories.

However, for the purpose of examining O&M costs through the period 2025 to 2029, it was necessary for the review to take into account the period of ramp-up in operations.

3.2.6 RAMP-UP

For Valley to Valley, the Authority assumed that the level of operations will be ramped up from a level of 70% (36 daily trainset runs) in the first year of revenue service (2025) to the full operation eight years later in 2033, an annual increase of 3.75%.

The degree to which the O&M costs in each category ramp up from a lower level in 2025 depends on the degree with which the costs in that category vary with the level of operations as shown in the following Table 5.

Table 5: Valley to Valley O&M Costs by Year

O&M costs	2025 ($m)	2033 ($m)	2025 as % of 2033
Operations	30.4	43.3	70%
Dispatching	12.5	12.8	98%
Maintenance of Equipment	21.6	47.9	45%
Maintenance of Infrastructure	55.9	56.5	99%
Station and Train Cleaning	21.5	21.8	99%
Commercial	41.7	65.3	64%
General and Admin	15.1	16.4	92%
Insurance	26.2	26.2	100%
Unallocated Contingency	9.0	11.7	77%
Total O&M Cost	**233.9**	**301.9**	**77%**

The review assessed the degree of ramp-up within each cost category and concluded that it is reasonable for:

- Operations cost to ramp up from 70% because this cost is almost all Driver/Conductor labor and energy which directly varies with Operations
- Dispatching, MOI and Station and Train Cleaning not ramp up at all because these costs do not vary with operations (and Insurance does not ramp up because the Authority is reviewing it)
- Maintenance of Equipment to ramp up not with operations but rather with the rate of procurement of the fleet of trains
- General Admin ramps up at a rate in between these extremes as it depends on the totals of the costs in the other categories.
- Unallocated Contingency stays consistent as a percentage of the total costs including allocated contingency

3.3 Summary of Review

Taken together, the results of the top-down and bottom-up reviews undertaken by the PFAL/FCP team provided reassurance that the O&M costs presented by the Authority across the entire suite of documents were based on a logical, coherent and clearly explained process of derivation from specification of level of operations through to ramp up over time to Steady State.

We are satisfied that the assumptions documented in the O&M Cost model documentation do form the basis for the O&M cost estimates.

Having established the logic of model cost derivation and the internal consistency of the documents we then reviewed the assumptions from a technical stand point.

This review identified some cost items that should potentially be included and/or increased as well as areas that we expect would result in lower O&M costs. These are discussed and evaluated (based on our use of the synthesized model) in Section 4, and their potential impact on the need for operating subsidy is presented in Section 5.3.

4. POSSIBLE ADJUSTMENTS TO THE O&M COSTS

PFAL and FCP noted both cost saving opportunities (Section 4.1) and cost increase adjustments (Section 4.2) to the Authority's O&M costs. For purposes of the analysis on whether the system would need an operating subsidy, and as we stated in Section 1.3, we focused mostly on the areas where costs could be higher than the Authority's projections.

4.1 O&M Cost Savings Opportunities

The following areas have been identified as presenting cost savings opportunities to the Authority, although we could only quantify item 3 below:

1. Staff Optimization: The current iteration of the model contains staff costs derived from basic assumptions on hours worked and working patterns. For example, train crews work five days per week completing one return journey per day with a productive working time of around 6 hours 15 minutes over an 8-hour tour. We would expect an operator to optimize both staff working arrangements and the location of crew depots to achieve higher levels of productive working time from staff.

2. Cost of Shared Facilities: The model includes the full cost of facilities that high-speed rail will share with other passenger rail services or other facilities users. While clearly a conservative cost assumption we would expect an equitable cost sharing arrangement to be put in place which would reduce the currently modeled O&M cost to the Authority.

3. Removal of Terminal Control Facilities from the model: In line with statements in the Authority's 2016 O&M Model Cost Model Documentation Report, we agree that the final design of the system and developments in operating practices may remove the need for these facilities and therefore their cost. The Authority stated to us its view that the removal of Terminal Control Facilities would reduce annual costs by $4.3 million, a view PFAL finds reasonable based on the Business Plan documentation we reviewed. Accordingly, we included this in our subsidy calculations (see Table 11), although we rounded the number to $4 million for simplicity in presentation.

4. Greater Efficiency from Train and Infrastructure Inspection Technology: Continued improvements in train inspection technology will increase the productivity of depot staff and result in financial savings. In the scenarios under review, the size of the train fleet is very small and without the critical mass to generate significant savings. Therefore, in the context of this review, we believe the potential cost reduction to be gained is small. However, we do believe that automating routine inspection of the infrastructure through train-borne and fixed monitoring equipment has the potential to materially reduce the currently modelled MOI costs, though by an amount difficult to specifically quantify and forecast with currently-knowable information. The Authority has stated that the use of this technology and a change in the currently mandated inspection regime is under discussion with the FRA.

Regarding the above items 1, 2 and 4, quantification is not possible at this time for the following reasons:

- Staff Optimization: The level of staff optimization possible will be driven by the service pattern and standards, location of facilities and the labor practices of the operator. Neither of these positions are currently fixed and therefore at this time we can only point to a potential, but unquantified benefit.

- Cost of Shared Facilities: The Authority has chosen to take a conservative assumption on these costs in the O&M Cost model and we assume that the final position will be the subject of a commercial negotiation between the parties. We have not challenged the Authority's assumption on this issue nor would it be appropriate to quantify a specific amount in advance of any commercial negotiation.

- Greater Efficiency from Train and Infrastructure Inspection Technology: As stated above, we believe that the potential cost reduction for MOI from this technology to be material. The quantum of any saving is largely dependent on approved changes to the currently mandated FRA inspection regime which we understand is a point of discussion between the Authority and the FRA. It would not be appropriate for us to quantify this impact in advance of the conclusion of these discussions.

4.2 Downward O&M Cost Adjustments

The review has identified a number of areas in the O&M Cost model where PFAL believes costs could be marginally higher than currently accounted for in the Authority's O&M Cost Model:

1. Overtime Payments: Paragraph 6 of the Universal Assumptions states "The model assumes that the system will be fully staffed such that no employee will need to work overtime and be paid at overtime rates." This is a valid assumption if everything always operates in the way it was intended to but in practice, there will be unexpected and additional requirements that are best met through the use of overtime. Service disruption resulting in longer work hours for depot, train and station staff is an obvious driver of overtime. To account for overtime we have modeled the cost of overtime at 10% of the basic manual staff cost. Beyond this level we consider that labor requirements should be met by additional resources rather than the use of overtime.

   We note above in section 4.1 bullet 1, that it can reasonably be expected that savings in staff costs will be achieved through optimizing the staff model. As optimization reduces the base staff cost, there will be a consequent reduction in the overall cost of overtime.

2. Retail System: No O&M costs have been included for the retail systems that will be required to: sell tickets, manage yields and protect revenue. We fully appreciate that the systems deployed will be an operator-led decision and that ticket retailing technology is currently going through a period of rapid change. However, it is certain that the operator will have to operate and maintain at a minimum:

   a. a back-end ticketing system
   b. facilities to transmit and read electronic tickets
   c. fixed and portable revenue protection equipment
   d. a yield management system of at least basic capability

   We have identified retail costs equivalent to 3.77% of revenue in the O&M Cost model covering call center charges, credit card commissions and station based staff. Our view is that the total cost of sales should be raised to 5% of revenue to cover items not currently identified in the O&M Cost model including: on-going system maintenance costs, data charges and ticket fulfilment[7]. As a comparison, the UK third party retail commission rate for internet train ticket sales are currently 5% plus fulfilment fees while the station sales commission rate is 9%.

   From discussion with the Authority we understand that at least some of the costs of the retail system may be treated as capital costs and therefore fall outside the scope of this Memo.

3. Rail Maintenance Vehicle Costs: Our analysis shows that in some instances the cost of rail maintenance vehicles allowed for in the model is lower than might be expected. Therefore, a contingency of 20% - in addition to the allocated contingency already assumed - has been added to the cost of the items where a

[7] Ticket Fulfilment being the cost of providing the customer with an actual ticket be that in paper or electronic form.

capital value as opposed to a benchmarked wet lease rate has been modeled. This is reflected in the table of adjustments below.

4. G&A Establishment: The model uses an assumption that the G&A headcount will be 10% of the manual labor headcount. While a reasonable assumption for an organization based on a single site we believe that a higher percentage is appropriate for an operation of this type. Therefore, the percentage size of the G&A establishment has been raised from 10% to 12.5% to better reflect the number of functions to be managed and the geographically dispersed nature of the workforce.

5. Ongoing Training: The model makes no specific assumptions for the cost of on-going staff training. Especially in the early years of operation continuing staff training will be an important feature of the system to ensure the efficient operation of a rail service that is attractive to customers. We have priced an adjustment to the O&M costs based on a number of assumptions contained in section 1.1 of the Technical Appendix below which would see all staff, depending on grade, receive either three or four days of training each year. Optimizing staff levels will affect training costs to some degree.

6. Cleaning Materials: The assumptions relating to train and station cleaning generate a reasonable level of labor for this activity but the model underestimates the cost of cleaning materials. Cleaning materials for this type of operation, including consumable cleaning machinery and equipment[8], should be no more than 10% of the labor cost and this factor is included below in the table of adjustments.

7. Train Maintenance Water Consumption: The model includes general depot water consumption but does not cover the cost of high-volume activities such as tank filling, train washing (where even a wash plant with water recycling will require fresh water to cover normal losses) and Controlled Emission Toilet ("CET") contents disposal. The calculation of the cost of this item is shown below in Table 6. During a discussion on February 10, 2017 the Authority stated that rain water harvesting and gray water recycling facilities are designed to make the depots neutral in terms of water consumption. While accepting this statement, the adjustment for train maintenance water consumption should be left in place for now and reviewed once depot plans have been finalized.

8. Specialist IT Systems: We would expect the operator to maintain a comprehensive website and to utilize a number of specialist IT systems including: customer information displays, public address systems, CCTV, security systems and control room systems. The assumptions on general IT are clear but we can find no reference to operating and maintaining specialist IT systems that will be required. As a general rule of thumb, the O&M cost of these systems is 10% of their capital cost but this will depend on the actual systems deployed.

9. Capability to Recover Failed Trains: The O&M model does not include any costs to provide a capability to recover failed trains such as dedicated rescue locomotives or call off agreements with third party locomotive operators. During a discussion on February 10, 2017 the Authority stated its plans for train rescue and passenger evacuation from failed trains do not require diesel locomotives as the service fleet will have the capability to carry out these tasks. We note this statement and agree with the principle of designing a system with in-built resilience and self-rescue / evacuation capability. However, our view and experience is that for the time being, the Authority should remain open minded on whether some form of self-powered rescue capability is required as it develops its strategy to recover trains during power outages or dewirements.

10. Facilities Management: We have found no costs for the day-to-day facilities management of stations, depots and offices. These costs would cover items such as routine maintenance of HVAC systems,

[8] Consumable cleaning machinery and equipment refers to items that can be used multiple times but are not capitalized due to their relatively short working life such as vacuums and floor scrubbers.

painting, decorating and minor repairs. A cost for this item has not been calculated and instead we suggest that the model is amended to reflect the emerging cost as the facilities to be maintained are designed. We do not expect this to change any conclusions reached below.

Table 6 quantifies the above PFAL and FCP opinion regarding the impact of the adjustments described above.

Table 6: Downward Cost Adjustments to the Modeled O&M Cost

O&M Cost Items	Annual Cost in Full Ramp-Up ($m)
Overtime Payments	$9.40
Retail System	$6.00
Rail Maintenance Vehicle Costs	$1.59
General Admin Establishment	$2.96
Ongoing training – *of which*	$1.57
- Drivers & Conductors	*$0.41*
- Other staff	*$1.11*
- Newly recruited Drivers	*$0.07*
Cleaning Materials	$1.02
Specialist IT Systems	$0.20
Train Maintenance Water Consumption	$0.08
Total PFAL Adjustment	**$22.84**

5. VALLEY TO VALLEY LINE OPERATING SUBSIDY REVIEW

This Memo reviews two scenarios to determine whether or not the planned passenger service to be provided by the Authority or pursuant to its authority will not require an operating subsidy. This section analyzes revenue and O&M costs specific to the Valley to Valley Scenario to form an opinion on the operating subsidy for the Valley to Valley Line. Section 6 of this Memo will address PFAL and FCP's PCEP Scenario operating subsidy review.

Section 5 is broken down into three sub-sections to summarize our findings and conclusions in regards to the operating subsidy review for the Valley to Valley Line. Those sections are: 5.1 Revenue Projections; 5.2 Valley to Valley Revenue and O&M Cost; and 5.3 Valley to Valley Operating Subsidy Analysis. PFAL and FCP reviewed the revenue projections and O&M costs for the Valley to Valley Line, and then compared the two to evaluate the potential for an operating subsidy.

5.1 Revenue Projections

PFAL and FCP conducted a separate independent review of the Authority's Ridership and Revenue Model, the final version of which is provided in Appendix B of this Memo. The Ridership and Revenue memo reviewed the Authority's ridership and revenue model and projections for the Valley to Valley Line, and is used to support the operating subsidy analysis in this Memo.

5.1.1 LOAD FACTOR REVIEW

A review of load factors was not included in PFAL and FCP's Ridership and Revenue memo, but is included in this section. A critical part of the assessment of whether the train service will be able to operate without subsidy is the confirmation that the defined level of service can support the associated forecasts of ridership and revenue.

Seat capacity provided

The modelled train service reviewed under this task order is made up of 44 single leg trips per day. The train procurement specification requires each train to have no fewer than 450 seats. Therefore, the minimum passenger capacity of the train service can be calculated as:

- 44 trips x 450 seats = 19,800 per day
- 19,800 seats x 365 days = 7.2 million seats per annum

Ridership

As described in the Authority's 2016 Business Plan, the medium level forecast Valley to Valley ridership is 7.5 million passengers per annum. Having 7.5 million passengers and only 7.2 million seats per annum suggests a load factor of over 100%, which seems unrealistic. But, the actual on-train load factors will be much less because many passengers will only ride part of the route, and some seats can therefore be "sold" twice.

Experience on other high-speed railways is that point-to-point routes can operate at an average load factor of around 80%. However, moving above this level in practice is difficult as, even with market pricing systems, demand will fluctuate throughout the day and seasons and it is not usually possible to sell all contra-peak and off-peak seats. Using sophisticated pricing systems, US airlines are able to achieve load factors of about 85%, but no higher.

Load factor analysis

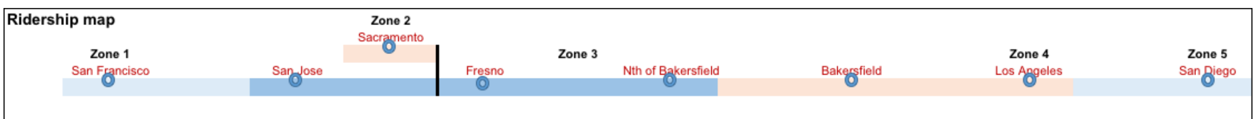
Table 7 below shows the ridership between origin and destination ("O-D") zones in absolute terms and with each O-D flow as a percentage of the total of 7.5 million riders.

Table 7: Ridership Between O-D Zones

VtoV Medium Level HS Rail annual ridership (millions)								
	To	1	2	3	4	5	6	Total
From		San Francisco	Sacramento	SJ Valley	Los Angeles	San Diego	Other	
1	San Francisco	0.232	0.022	2.227	1.476	0.115	0.717	4.789
2	Sacramento		0	0.123	0.173	0.012	0.07	0.378
3	SJ Valley			0.682	0.605	0.09	0.508	1.885
4	Los Angeles				0	0	0.304	0.304
5	San Diego					0	0.025	0.025
6	Other						0.08	0.08
								7.461
	To	1	2	3	4	5	6	Total
From		San Francisco	Sacramento	SJ Valley	Los Angeles	San Diego	Other	
1	San Francisco	3%	0%	30%	20%	2%	10%	64%
2	Sacramento		0%	2%	2%	0%	1%	5%
3	SJ Valley			9%	8%	1%	7%	25%
4	Los Angeles				0%	0%	4%	4%
5	San Diego					0%	0%	0%
6	Other						1%	1%
		3%						100%

Table 8 below plots these zone to zone O-D flow percentages against the route sections that they will be using to establish what percentage of the 7.5 million passengers would be using each route section, and therefore the ridership on each route section.

Table 8: O-D Flow Percentages



OD Zone							
1 to 1	3%						
1 to 3	30%	30%	30%				
1 to 4	20%	20%	20%	20%	20%	20%	
1 to 5	2%	2%	2%	2%	2%	2%	2%
1 to 6	10%	10%	10%				
2 to 3			2%	2%			
2 to 4			2%	2%	2%	2%	
3 to 3				9%			
3 to 4				8%	8%	8%	
% of Total Ridership	64%	61%	65%	43%	32%	32%	2%
Ridership in Millions	4.77	4.54	4.83	3.17	2.37	2.37	0.12
% Load Factor	**66.21%**	**62.99%**	**67.10%**	**44.08%**	**32.90%**	**32.90%**	**1.60%**

A load factor for each route section was calculated using the capacity provided of 7.2 million seats end-to-end and these are shown in the last line of the diagram.

This analysis shows that in fact only 22% of the forecast journeys will be end-to-end, with the remaining 78% taking place over sections of the route. The maximum implied load factor is only 67%, well below the load factors achieved on point-to-point high-speed rail routes and on US airlines.

During the ramp-up period, in 2029 when ridership reaches 100% (7.5 million riders) and operations is still at only 85%, 37 high-speed rail services will yield 6.2 million seats. Our analysis shows the maximum load factor will be 78%.

Using the Authority's assumptions for capacity and ridership it can be concluded that the planned level of service on the Valley to Valley will be sufficient to support the forecast levels of ridership and hence revenue.

Ancillary Revenues

PFAL and FCP's memo on Ridership and Revenue only contemplated at fare revenues. The Authority's business plan assumes that ancillary revenues would be 1% of fare revenues. The O&M cost estimates assumed no provision of on-board food and beverage services, and had no specific provision for the O&M costs of parking facilities. We understand that the Authority is planning to install automatic ticket gates at most or all stations. There will also be substantial parking lots at most stations. There is provision for four customer-facing staff on all trains. There do therefore seem to be substantial opportunities to increase revenues, with much lesser cost impacts, by charging for parking at stations and by using some staff to sell food and beverages on trains. The ridership and revenue forecasts did assume that passengers would need to pay to park at stations, but did not explicitly include any amount of revenue this would generate in the forecasts. International experience on similar corridors is that ancillary revenues, including parking revenues and margins on food and beverage sales, can exceed 5% of total revenues. We did not include any ancillary revenue below because at present the O&M Cost model does not fully reflect the cost of generating this revenue.

5.2 Valley to Valley Revenue and O&M Cost

The forecast of revenue and O&M cost for operating the Valley to Valley service through 2039 as presented by the Authority is shown in Table 9.

Table 9: Authority's Valley to Valley Revenue and O&M (central case)

Authority Figures (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Farebox Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
O&M Cost	234	251	266	283	282	286	292	296	302	302	303	303	304	305	305

Note: these costs include an adjustment of $6.5 million per annum ("pa") related to protect crews and MOI Basic Facility day gangs which was added in on the Authority's advice as described in Section 3.2.5 above.

We have verified that these O&M costs are consistent with the Authority's documented assumptions, including an 8-year ramp-up from 70% of operations in 2025 to 100% in 2033. In addition, we have verified that these revenue forecasts are consistent with the Valley to Valley revenue forecast from the 2016 Business Plan, with a 5-year ramp-up from 40% in 2025 to 100% in 2029.

5.3 Valley to Valley Operating Subsidy Analysis

To evaluate whether the Valley to Valley Line will require an operating subsidy, we conducted a series of tests. We first looked at the Authority's base-case figures (Table 10), adjusted the revenue and cost figures based on our view of the upward and downward adjustments that could be quantified (Table 11), and then ran two additional sensitivity tests looking at the robustness of the forecasts in light of potential pessimistic situations (Tables 12 and 13).

The forecasts shown in Section 5.2 above, as presented by the Authority, indicate that the revenue from the high-speed train operations on the Valley to Valley Line will exceed the O&M costs in 2026, and will continue to do so thereafter if the Authority's assumptions materialize. This is shown in Table 10 below:

Table 10: Valley to Valley Operating Surplus / Deficit (Authority's Central Case)

Authority Figures (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Farebox Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
O&M Cost	234	251	266	283	282	286	292	296	302	302	303	303	304	305	305
Surplus/(Deficit)	**(43)**	**12**	**68**	**124**	**197**	**200**	**201**	**204**	**205**	**212**	**219**	**226**	**232**	**240**	**247**

In Section 4 we highlighted upside areas where we believe the Authority's costs could be reduced (quantifying one of them), and quantified potential additional costs from our review of the O&M model and documentation. The costs that we were able to quantify have been added to the Authority's modeled O&M cost to create an adjusted PFAL O&M cost. Taking the adjusted PFAL O&M cost together with the revenue numbers (see Table 11) results in a conclusion that revenue from high-speed train operations on the Valley to Valley Line will exceed O&M costs in 2026, and will continue to do so thereafter.

As stated in Section 5.1, PFAL and FCP conducted a separate independent review of the Authority's Ridership and Revenue Model, the final version of which is provided in Appendix B of this Memo. The Ridership and Revenue memo reviewed the Authority's ridership and revenue model and projections for the Valley to Valley Line, and is used to support the operating subsidy analysis in this Memo. In Tables 11 and 12, PFAL used the Authority's farebox revenue figures after independently verifying them in the Ridership and Revenue memo in Appendix B.

Table 11: Valley to Valley Operating Surplus / Deficit (with PFAL Adjustments)[9]

PFAL Adjustments (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Farebox Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
Authority O&M cost	*234*	*251*	*266*	*283*	*282*	*286*	*292*	*296*	*302*	*302*	*303*	*303*	*304*	*305*	*305*
Quantified Upside	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*
Total PFALO&M Adjustments	*17*	*18*	*19*	*20*	*22*	*21*	*22*	*22*	*23*	*23*	*23*	*23*	*23*	*23*	*23*
PFAL Adjusted O&M Cost	246	265	281	299	299	303	309	314	321	321	322	322	323	324	324
Surplus/(Deficit)	**(55)**	**(2)**	**53**	**108**	**180**	**182**	**183**	**186**	**186**	**194**	**200**	**207**	**213**	**221**	**228**

5.3.1 SENSITIVITY TESTING FOR VALLEY TO VALLEY OPERATING SUBSIDY

Sensitivity testing has been undertaken to assess the robustness of the conclusion that no operating subsidy will be required. The sensitivity tests were carried out using the adjusted O&M costs, i.e. including the downside items.

In the first test, scenario 1 (Table 12), full Steady State costs (including the PFAL adjustments) were applied from year 1. Revenue exceeded costs from year 3 and continued to do so thereafter.

Table 12: Sensitivity Scenario 1 - Full Steady State PFAL Adjusted O&M Cost from year 1

PFAL Adjustments (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Authority Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
PFAL Adjusted O&M Cost	321	321	321	321	321	321	321	321	321	321	322	322	323	324	324
Surplus/(Deficit)	**(129)**	**(58)**	**14**	**86**	**158**	**165**	**172**	**179**	**186**	**194**	**200**	**207**	**213**	**221**	**228**

[9] Rounding accounts for slight differences in summation in this table and in the scenarios that follow in Sections 5 and 6.

In the second test, scenario 2 (see Table 13), we assessed the impact of taking revenue at the low end of the 90% confidence interval reported in the PFAL/FCP review of Ridership and Revenue, which was 58% of the Cambridge Systematics (the Authority's ridership consultant) forecast and all of the O&M adjustments described above. In this scenario, revenue does not cover costs until the last two years of the review. This scenario recognizes (and mathematically accounts for) two areas of cost savings resulting from the lower passenger numbers that easily can be derived and quantified using the synthesized model. We note, however, that this scenario ignores the upside opportunities we have identified, including the potential O&M cost reductions, does not take into account ancillary revenue, and does not assume other (more difficult to quantify) cost-savings adjustments in operations or service based on the lower passenger volumes. It is therefore highly likely that taking these opportunities into account would allow the service to operate without subsidy even in this very pessimistic scenario. This is an extreme downside scenario.

Table 13: Sensitivity Scenario 2 - 58% of Revenue forecast (from PFAL Ridership and Revenue Memo) and PFAL Adjusted O&M Costs

PFAL Adjustments (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
PFAL Adjusted Revenue	111	153	194	236	278	282	286	290	294	298	303	307	311	316	320
PFAL Adjusted O&M	246	265	281	299	299	303	309	314	321	321	322	322	323	324	324
Call Center & CC Commission Saving	(3)	(3)	(4)	(5)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)	(6)
Retail System Savings	(1)	(1)	(2)	(2)	(3)	(2)	(2)	(2)	(3)	(3)	(3)	(3)	(3)	(3)	(3)
Surplus/(Deficit)	**(132)**	**(107)**	**(81)**	**(55)**	**(12)**	**(13)**	**(15)**	**(16)**	**(18)**	**(14)**	**(10)**	**(7)**	**(3)**	**1**	**5**

In summary, the results of PFAL and FCP's analysis indicate for the Valley to Valley Line:

- we conclude that it is likely that the Valley to Valley Line can operate without subsidy after an initial start-up period based on central case assumptions (described below);
- the Authority's modelled central case, as defined by the Authority in the 2016 Business Plan, for the Valley to Valley Line O&M cost is substantially lower than the Authority's modelled central case for the Valley to Valley Line revenue in each year of operation from 2025 to 2039, apart from 2025 which is the first year of operation. O&M costs under these conditions are 55% - 60% of forecast revenue during the post 2032 steady-state years;
- when evaluated against the additional adjustments PFAL and FCP identified, as noted above, the Valley to Valley line can be operated on an ongoing basis without subsidy based on central case assumptions, as forecast revenue will exceed the adjusted modelled O&M costs from the third year of operation;
- in the review of revenue, FCP and PFAL concluded there was a 90% probability that revenues would be at least 58% of the Authority's forecast. If in fact ridership is only 58% of projected levels, there would be other cost saving opportunities (e.g. some services might be curtailed and on-board crew might be reduced). When evaluating the Valley to Valley line, PFAL adjusted O&M costs against the 58% of revenue scenario, and operations are found to have a surplus starting in year 2038. These changes, and the other un-quantified cost savings we have identified, likely could allow the service to operate without subsidy even in this very pessimistic revenue scenario; and
- there also may be various additional ancillary revenue opportunities, most notably from car parking, and also from on-board food and beverage sales. The Authority revenue forecasts assumed that ancillary revenues are only 1% of fare revenues, which is very cautious.

6. PCEP SCENARIO OPERATING SUBSIDY REVIEW

This section reviews whether or not the PCEP Scenario requires an operating subsidy. The Authority provided cash flow forecasts for the PCEP Scenario comprising forecasts of Revenue and O&M cost by category for the years 2025 to 2039.

6.1 PCEP Scenario Steady State Costs

For the first fully ramped-up year (2033), the Authority's figures show that the incremental O&M cost of the PCEP scenario relative to Valley to Valley is $12m as shown in Table 15.

Table 14: Steady State O&M Costs for PCEP Relative to Valley to Valley

O&M costs	Valley to Valley	PCEP	Increment
Operations	43.3	45.6	2.3
Dispatching	12.8	12.8	-
Maintenance of Equipment	47.9	49.1	1.2
Maintenance of Infrastructure	56.5	56.5	-
Station and Train Cleaning	21.8	24.9	3.1
Commercial	65.3	69.9	4.6
General Admin	16.4	16.8	0.4
Insurance	26.2	26.2	-
Unallocated O&M Contingency	11.7	12.2	0.5
Total	**301.9**	**314.0**	**12.1**

The synthesized cost model verified that the incremental costs in each category are consistent with the Authority's documented assumptions

- Operations: an extra 600,000 trainset miles per year results in an incremental energy cost of $2.3 million
- MOE: having 16 trainsets rather than 13 means the materials costs for inspections and overhauls increase by $1.2 million per year
- MOI: the MOI cost of the Peninsula Corridor is already included in the MOI cost of the Valley to Valley as, in the absence of completed cost sharing agreements, the Authority has already assumed the full cost of shared facilities.
- Station and (in-station train cleaning): the addition of San Francisco (Level A) station causes an increase of 50 station operations and cleaning staff at an incremental cost of $3 million per year
- Commercial: an increase in Revenue of $120 million causes an increase in credit card charges of $4.6 million per year
- General Administration: the increased labor force causes and increase in General Admin positions at an incremental cost of $0.4 million per year
- Unallocated contingency: the increased cost in the other categories results in an increment of $0.5 million per year

The PFAL and FCP team has verified that these increments in staff numbers and costs are reasonable relative to the conclusions we have drawn with respect to the Valley to Valley scenario.

6.2 PCEP Scenario Operating Subsidy Analysis

The Authority's forecasts for Revenue and O&M Costs (after adding back in Protect crews and Basic Facility MOI staff as discussed above) for the PCEP Scenario for 2025 to 2039 are as shown in Table 15.

Table 15: PCEP Scenario Surplus / Deficit

Authority Figures (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Revenue	241	331	422	512	603	612	620	629	638	648	657	666	676	686	695
O&M Cost	240	257	274	290	293	297	303	306	314	315	316	316	316	318	318
Surplus/ (Deficit)	**1**	**75**	**148**	**223**	**310**	**314**	**317**	**323**	**324**	**333**	**341**	**350**	**359**	**368**	**377**

The Authority's revenue forecasts for the PCEP Scenario have not been separately validated by PFAL and FCP (although we did validate the Valley to Valley Line scenario and the Valley to Valley Extended scenario included in Appendix B, which bracket the PCEP scenario). Therefore, in this analysis we have taken a conservative approach of only assuming the Valley to Valley revenue forecast (essentially not taking into account any revenue from the extension of service from San Jose to San Francisco). Even with this conservative assumption of only Valley to Valley revenue, the PCEP Scenario can operate without subsidy over the period 2025 to 2029 and continue to do so thereafter under the central case assumptions.

Table 16: PCEP Surplus / Deficit Using Only Valley to Valley Revenue

Authority Figures (in 2015 $m)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
VtoV Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
PCEP O&M Cost	240	257	274	290	293	297	303	306	314	315	316	316	316	318	318
Surplus/ (Deficit)	**(49)**	**7**	**61**	**117**	**186**	**188**	**190**	**193**	**193**	**199**	**206**	**213**	**220**	**227**	**234**

We derived a set of PFAL adjusted PCEP O&M costs by including the potential upside and downside impacts discussed in Section 4 and calculated the surplus/(deficit) when these adjusted costs are compared to the Valley to Valley revenue. Table 18 shows that even under these more conservative assumptions, the PCEP Scenario revenue would cover its O&M costs by 2027 and continue to do so thereafter under central case assumptions.

As stated in Section 5.1, PFAL and FCP conducted a separate independent review of the Authority's Ridership and Revenue Model, the final version of which is provided in Appendix B of this Memo. The Ridership and Revenue memo reviewed the Authority's ridership and revenue model and projections for the Valley to Valley Line, and is used to support the operating subsidy analysis in this Memo. In Table 17, PFAL used the Authority's farebox revenue figures after independently verifying them in the Ridership and Revenue memo in Appendix B.

Table 17: PCEP Surplus / Deficit - PFAL Adjustments

PFAL Adjusted (in 2015 $)	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039
Authority VtoV Revenue	191	263	335	407	479	486	493	500	507	514	522	529	537	544	552
Authority O&M cost	*240*	*257*	*274*	*290*	*293*	*297*	*303*	*306*	*314*	*315*	*316*	*316*	*316*	*318*	*318*
Quantified Upside	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*	*(4)*
PFAL Downside Adjustments	*17*	*18*	*19*	*20*	*22*	*21*	*22*	*22*	*23*	*23*	*23*	*23*	*23*	*23*	*23*
PFAL Adjusted O&M Cost	252	270	289	306	310	315	321	325	333	334	335	335	335	337	337
Surplus/(Deficit)	**(61)**	**(7)**	**46**	**101**	**169**	**171**	**172**	**175**	**174**	**180**	**187**	**194**	**201**	**208**	**215**

In summary, the results of PFAL and FCP's analysis indicate for the PCEP Scenario:

- We assumed additional costs, but no additional revenues, for the PCEP Scenario, we conclude also that it is likely that this service too can be operated without subsidy after the initial start-up period based on central case assumptions;
- the addition of services to San Francisco under the PCEP Scenario is modelled by the Authority to increase O&M costs by $12 million per year, which does not lead to a requirement for a subsidy in the Valley to Valley Line central revenue case (except in 2025), even under the conservative approach where no additional revenue is assumed for the extension to San Francisco from San Jose. With the incremental O&M costs for service to San Francisco plus the adjustments PFAL and FCP identified for the Valley to Valley Line - but no assumed additional revenue - the O&M cost is about 65% of the revenue at Steady State, leaving a surplus of nearly $165 million at the start of full ramp up rising to a surplus of just over $200 million per annum in the period reviewed;

7. CONCLUSIONS

Our analysis of the Authority's O&M Cost model, associated documentation and comparison with the ridership and revenue forecast has reached the following conclusions with regard to Valley to Valley and PCEP scenarios:

1. The modeled O&M cost for the Valley to Valley service reviewed is lower than the forecast revenue in each year of operation from 2025 to 2039 apart from 2025 which is the first year of operation, thus not requiring an operating subsidy based on our analysis of the Authority's assumptions.

2. When the Authority's O&M cost is modified for PFAL's adjustments that can be quantified for the Valley to Valley or for the PCEP scenario, O&M costs remain lower than the forecast revenue in each year of operation from 2025 to 2039 apart from 2025 and 2026, which are the first two years of operation, maintaining the conclusion that both scenarios do not require an operating subsidy based on our analysis of the Authority's assumptions.

3. At Steady State the O&M costs are forecast to be 60 - 63% of revenue in 2033, the first year of Steady State operations, depending on whether the Authority's costs or the PFAL adjusted costs are used, and this ratio decreases to 55% - 59% by 2039, the end of the review period, as the revenues are forecast to increase more quickly than the costs.

4. PFAL and FCP's ridership and revenue analysis concluded there was a 90% probability that revenues would be at least 58% of the Authority's forecast. When comparing the scenario of 58% of revenue compared to PFAL's adjusted O&M costs, operations will have a surplus starting in year 2038.

5. These findings and conclusions are based on the Authority's current assumptions and information, which PFAL concluded were reasonable, and are subject to change as the Authority develops its approach for an operator and rolling stock provider.

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APPENDIX A

The Technical Appendix A is laid out in the same order and under the same main headings as the Operations & Maintenance Cost Model 2016 Business Plan: Technical Supporting Documents. It contains our detailed findings and comments on the O&M costs and supports the conclusions in the memo.

1. UNIVERSAL ASSUMPTIONS

1.1 Introduction

The Universal Assumptions set the basic parameters for modelled labor costs. In addition, paragraph 4.2 confirms that the system design and characteristics used in the O&M Model have been obtained from the document titled "2016 Business Plan and Technical Supporting Document: Service Planning Methodology".

For the purposes of this review, we have taken the system design and characteristics, labor rates, fringe rates and indexation rates to be correct and these have not been subject to further validation. We have restricted our review to assumptions that are used to manipulate these basic inputs, the results of which are shown below.

- Paragraph 6 – Overtime assumption. The model assumes that a full staff establishment is maintained and that this removes the need for overtime payments. We support the modelling of a full staff establishment but believe that even with this some overtime will be required to cover such events as exceptional short-term staff unavailability and additional staff hours due to operational disruption. The range of likely overtime costs is between 5% and 10% of basic labor costs and an adjustment has been made to the modeled O&M cost at the upper, i.e. 10%, level.
- Paragraph 7 – Frontline supervision. The model assumes supervisors will comprise 5% or 1 in 20 of the total workforce. While generally correct, this assumption is not appropriate where staff requiring supervision work in groups of less than 20 that cannot be aggregated into larger groups due to geographical location or divergent skills. Duties at stations are one example where this would be the case. In terms of the model this is a point of detail and overall, we believe the financial impact of this issue to be immaterial in cost terms.
- Paragraph 8 – General and administrative staff. No comment.
- Paragraph 9 – Supervisory wage enhancement. No comment.
- Paragraphs 10, 11 and 12 – Availability factors. The availability factors have been reviewed and the logic applied judged to be sound.
- Paragraph 13 – Working week. The model assumes that train crew will work a fixed shift pattern with an un-optimized roster. We would expect a commercial operator to optimize the roster and achieve a higher level of labor efficiency than currently assumed. We have not attempted to quantify the possible level of upside achievable through roster optimization.
- Paragraph 16 – Cost of shared facilities. This assumption is conservative in cost terms and we would expect actual costs to be lower than modeled to reflect reasonable cost sharing arrangements.

The model makes no specific assumptions for the cost of on-going staff training. Especially in the early years of operation continuing staff training will be an important feature of the operation to ensure the efficient operation of an attractive rail service. We have costed an adjustment to the O&M costs based on a number of assumptions which would see all staff, depending on grade, receive either three or four days of training each year:

All Grades Except Drivers and Conductors

- Assume that the G&A budget already covers the cost of trainers
- Staff get 3 rostered training days per annum
- Training covers grade specific customer service or technical skills

Drivers and Conductors

- Both get 4 rostered training days per annum, as above for costs
- Training covers grade specific customer service, technical skills and required safety learning
- We assume all drivers and conductors come fully trained from other operators and therefore new recruits require a conversion course only to the new rolling stock and not training for the role from scratch
- New recruits into driver or conductor positions will be unproductive for three months while go through their training program
- During ramp up the operation will train the difference between initial establishment and full establishment + 10%
- Post ramp up, the operation will train the equivalent of 5% of the driver and conductor establishment each year to ensure that it remains fully staffed with competent personnel

The annual cost of staff training is $1.59 million and is shown in Table 1 of the Memo above by grade.

2. TRAIN OPERATIONS COSTS

2.1 Related Personnel

The personnel proposed for train crewing appear to be in line with conventional US passenger train operations and there is thus an opportunity for a commercial train operator to make some efficiency savings in crew costs.

In our view, it is essential that long-distance passenger train operations should provide food and refreshments on board. At present the model does not include the costs or revenues of such an on-board service and we note the Authority's view that this is a decision for the operator and on this basis, we have not made an adjustment to the O&M cost to cover this activity, nor have we considered the revenues that might be generated.

2.2 Assumptions and Model Inputs for Train Operations Personnel

The review team considers that the assumptions used in the model are reasonable and form a good basis for the costing of train operations personnel.

2.3 Energy Costs

The energy consumption shown in the model input is consistent with what might be expected from French and German high-speed train sets.

2.4 Uniforms, Vehicles and Supplies

The assumptions for uniforms, vehicles and supplies are generally appropriate and we have just one minor comment relating to cell phones. Good communication with on-board staff is essential for the smooth running of the service and we would advise that as a minimum each Conductor and the lead member of the customer service team be equipped with a cell phone.

3. DISPATCHING AND CONTROL COSTS

3.1 Related Personnel

The model commentary reflects the developing position on how dispatching and control will be carried out in practice. Some costs were removed from the 2016 Business Plan with the decision to move from a region control center approach to a centralized Operations Control Center. A further reduction in personnel is expected once the track and station design has been finalized as it is believed that this will facilitate further savings.

Following a discussion with the Authority on the 10th February 2017 the Authority has valued the cost saving from the removal of Terminal Control Facility Staff at circa $4.3 million per annum in 2033. This upside adjustment has been reflected in our conclusions.

3.2 Assumptions and Model Inputs

The model assumes that the Operational Control Centre is staffed on a 24-hour basis which accurately reflects the fact that control functions are required outside of train running hours.

A reduced level of dispatch staff is assumed for stations outside of train running hours and at the current level of model design this assumption is appropriate. Once the design of stations and operating plans have been developed then there may be a need to adjust staffing levels and shift patterns at stations to ensure that service start-up and wind-down are adequately covered by dispatch staff. We would expect this to be more a case of re-allocating the existing modeled level of resource rather than providing additional resources and therefore no cost adjustment is recommended at present.

3.3 Vehicles and Supplies

Two vehicles are assumed to be required, based at the Operations Control Center, to aid response to incidents and travel between locations when rail is not an option. The model also allows for vehicles based at each terminal and the HMF. Overall, the level of vehicles provided across the model is reasonable.

The assumptions relating to supplies appear appropriate.

4. MAINTENANCE OF EQUIPMENT COSTS

4.1 Related Personnel

Our analysis of the MOE personnel requirement for a fleet of 13 trains concluded that the assumptions used in the O&M model generate an appropriate staffing establishment in terms of overall size and cost. Within the overall establishment, our distribution of staff by grade and function differed from that modeled and in particular, we calculated that more materials management and data analysis staff would be required and less technicians. However, these differences in the detail of personnel do not result in a materially different cost to that contained in the Authority's model.

4.2 Assumptions and Model Inputs

The train fleet will require a mid-life overhaul and following a review of the documents a clarification question on this point was asked of the Authority. The response from the Authority stated that this activity is part of the system's lifecycle costs and thus falls outside of the remit of the Task Order for this report and therefore we have drawn no conclusions on this matter.

The current iteration of the model does not contain detail around some O&M activities such as periodic replacement of internal furnishings, nor does it detail how the obsolescence of electronic components and systems will be dealt with. On this point, the Authority has responded that this is one or two levels of detail beyond the intermediate nature of the current model. We of course accept this point and merely note that these issues should be taken into account as the model develops.

The O&M model assumes that the trains arrive as specified, fully commissioned and ready for service and that all necessary depot, maintenance facilities and capital spares have been procured with the train and the necessary staff training and mobilization is complete. There is significant cost associated with delivering this assumption which is not included in the O&M model but we have been advised is covered elsewhere in the Authority's financial plans as the O&M analysis starts at the beginning of the revenue service period.

The O&M model provides for a bogie overhaul at 600k miles intervals with every third overhaul requiring new wheels. Practical experience with high-speed trains running on mixed traffic lines suggests a wheel life of ~1 million miles. It is assumed that adjusting the plan to a 10^6 mile bogie overhaul and wheel replacement regime will be cost neutral.

During discussions the Authority confirmed that it's O&M projections assumed that rescue locomotives would not be required due to the high reliability of the EMUs, and because a failed EMU could always be rescued by another nearby EMU (pulled or propelled), although at lower speed. In our view an operator would want to have standby diesel locomotives for commercial reasons even if not strictly required by code. In the event of a dewirement or failure of the power supply, there could be thousands of people stuck on trains. Evacuation from a stalled train is slow and potentially hazardous. It would also cause enormous reputational damage, if done badly. Locomotives used for rescue work should be capable of delivering hotel power to failed trains in addition to motive power.

The need for these locomotives may be mitigated if the railways' system is engineered to provide for:

- A track layout such that the onboard train emergency ramps can be deployed to detrain passengers for evacuation. These train born ramps make it possible for a train-to-train evacuation (i.e. passengers will be able to use the ramp to walk from the disabled train to a train on the adjacent track directly), or where this is not possible a train-to-ground evacuation whereby the evacuated passengers should be able to exit the train to the emergency walkway without having to walk on the track formation/ballast.
- That trainsets will be provided with a battery powered ventilation systems that will operate up to 90 minutes, giving the OCC time to implement mitigating actions.
- That the trains are fitted with two pantograph types to cater for two wire design heights, 17.5 feet and 24 feet.
    - On the dedicated CHSR high-speed tracks (which includes Valley to Valley) there will be no freight operations and the contact wire height will be designed and installed at 17.5 feet (5.3 meters).
    - On the shared sections, where the CHSR trains will operate in Tier 1 territory, the contact wire will be installed at 24 feet (7.3 meters) to accommodate the existing freight operations on those sections; here the CHSR high-speed trainsets will use a second long-reach pantograph but speeds will be limited to Tier 1 speeds (< 125 mph).

The two basic failed train operating scenarios to consider are:

- Normal operation; here the quickest way to reach a failed trainset is by using a following HSR train. Assuming a non-peak operation with 2 trains per hour, the following train is no further than 30 minute behind and trains in the opposite direction will be upon a failed trainset in less than 30 minutes.

- A failure of normal operation, i.e. a dewirement so there is no rescue EMU possibility in the safe 90 minute period. The failed train will then evacuate to a place of safety for a bus rescue.
- This preferred modus operandi are in in line with many high speed operators around the world.

It is considered that these shared sections of track will have the highest risk of dewirements and the operator will need to consider the options available in such an event. At the very least there will be a need to be capable of moving stranded trains out of the way of the repair train to allow work to commence, so as a minimum the operator's maintenance locomotives will need to be capable of safely moving the EMU's away from the work area. We note that shared infrastructure presents particular issues to resolve as its design will not facilitate train to train passenger transfer and the mixed traffic carried may mean that a failed EMU is separated from the next EMU by other classes of passenger or freight train. Therefore, the ability to connect a second EMU to effect a rescue may be restricted.

4.3 Utilities

The model has costs for general power and water consumption which appear reasonable. However, we can find no costs for water consumption and sewerage disposal relating to train maintenance activities. We assume that trains will be washed after 36 hours in traffic at the same time as CET tanks are emptied and water tanks filled. Based on the number of vehicles and the frequency of servicing we have calculated that the HMF will consume 3,400 hundred cubic feet (CCF) of fresh water per annum and dispose of 2,000 CCF of sewerage. The cost for fresh water and sewerage charges is estimated to be $80,000 pa. Due to the relatively low cost of this item we do not suggest that an adjustment is made to the O&M model at this time.

During a discussion on 10th February 2017 the Authority stated that rain water harvesting and gray water recycling facilities are designed to make the depots neutral in terms of water consumption. While accepting this statement the adjustment for train maintenance water consumption should be left in place for now and reviewed once depot plans have been finalized.

5. MAINTENANCE OF INFRASTRUCTURE

5.1 Related Operating Personnel

The review started with a top down approach by seeking to validate the overall MOI budget for the Valley to Valley section. This was done by looking at other similar or comparable routes and their maintenance budgets. Published information often includes unseen variables but it is noted in this exercise that the overall MOI costs shown in the business plan are in excess of other similar rail routes and therefore do not represent a threat to the viability of the operation.

The organization charts show adequate staffing for a section of line 100-150 miles long as described in the text but there is no visible staff for data processing technical staff to cover computer systems or SCADA. The reviewers suggest that costs for these items should be built in to the model as it develops.

The descriptions of maintenance units in Para. 8.2.1 appear to cover most of the essential disciplines but there are no references to earthworks and vegetation maintenance. In conversation with the Authority, we were told that this work was included within the duties of the planned staff.

At present, the model reflects manual rather than automated inspection of the infrastructure. Experience from other systems shows that costs can be materially reduced through replacing manual inspection regimes with automated ones using a mix of train-borne and fixed monitoring equipment. We understand that the Authority is in discussion with the FRA on this matter and subject to an agreement would expect to see a cost reduction in future iterations of the O&M Cost model.

5.2 Assumptions and Model Inputs

While the business plan appears to cover the period from 2025 onwards, it is noted by the reviewers that maintenance activity should commence at substantial completion rather than the start of operations. Therefore, costs will be incurred before the time period of the O&M model.

In para 3.3 of the O&M Cost model, there is a reference to a “Ramp Up” period of 8 years from start of service but there is no indication of the commissioning and training time in the period before 2025. After consultation with the Authority, we were advised that these costs were to be considered as capital costs for the completion of system development, and therefore do not form part of this review.

The O&M Cost model shows a comprehensive list of maintenance vehicles and equipment. It is noted that, in the equipment lists, the following items are listed but no number is provided: Tractor with Low Boy & Flatbed Trailer, Kirov Crane, 2 Piece Wire Stringing Unit.

The Authority advised us that the tractor-trailer and the Kirow crane are listed in the table because they are included in the model but, they are not part of the Basic MOI Facility, Initial System, HMF Addition or Facility Gang Addition units. However, it is intended to provide one of each for surfacing in the PH1 maintenance regime. They also told us that the 2 Piece Wire Stringing Unit is only part of the Second System Unit, which has been removed from the 2016 model. The Authority informed us that the Basic MOI Facility and Initial System Unit totals in Table 17 should be 57 and 13, respectively.

The prices for flat cars shown in the document are low. Used railroad cars are shown for sale at $17-20,000. A new flat car was quoted as $70,000 in 2010. (A Preliminary Investigation of Private Railcars in North America Author(s): Thomas M. Corsi, Ken Casavant, and Tim A. Graciano Source: Journal of the Transportation Research Forum, Vol. 51, No. 1 (Spring 2012), pp. 53-70 Published by: Transportation Research Forum). The WSJ reports the average cost of a locomotive in 2014 was $2.5 million (14 July 2014).

As a result of these findings, it is suggested that the proposed prices for maintenance equipment is at the low end of the range. It is suggested that a detailed review of equipment prices should be undertaken to validate purchase and leasing costs. For the purpose of this review, a contingency of 20% has been added to the vehicle purchase costs (for those vehicles whose prices were not based on actual wet rates on existing railroads) to bring these to a more realistic level in the opinion of the reviewers.

It may be noted that the cost of maintaining railroad track in the US is quoted as $50,000 per track km per annum. (Santa, J.F., Toro, A. and Lewis, R., 2016. Correlations between rail wear rates and operating conditions in a commercial railroad. Tribology International, 95, pp.5-12). This equates to $80,000 per track mile. A study of 2010 (Rocky Mountain Rail Authority High-Speed Rail Feasibility Study Business Plan 2010) suggested $50,000 per track mile. The average additional annual cost for electrified track is $25,000 per mile (Rocky Mountain Rail Authority High-Speed Rail Feasibility Study Business Plan, 2010).

Compared with the Authority’s figures in the MOI part of the Business Plan cost model, the Authority’s figure of around $106,000 per track mile is comfortably above the $75,000 figure.

It is noted for the Authority’s information that experience shows that slab track on a high-speed railway will have a better life cycle cost than ballasted track. The life cycle plot shows that the increased cost of building slab track are recovered in 9 years of maintenance savings (Takai, H., 2007. 40 years experiences of the slab track on Japanese high-speed lines).

5.3 Uniforms, Supplies and Information Technology / Software

In para. 8.2.5 it is noted that the allowance for materials for MOI is 15% of total labor cost in line with UIC information. This is considered adequate assuming that no replacement of track, signaling or OCS components is included in the work requirements and is part of the system's lifecycle costs.

6. STATION OPERATIONS AND TRAIN AND STATION CLEANING

6.1 Related Personnel

The model identifies the customer facing classes of staff required to operate stations. Police and security staff, who will in part be based at stations, are covered separately in the next section.

However, the model does not identify any personnel or costs required to maintain the stations beyond cleaning. Facilities management, running repairs and decorating / minor refurbishment will be required at stations to maintain an attractive customer environment that supports revenue generation. This appears to be an omission from the model that requires adjustment.

6.2 Assumptions and Model Inputs

6.2.1 STATION OPERATIONS STAFF

Passengers value a staff presence at stations and the model assumes that all stations will have customer facing staff on duty during train running hours. Staffing the stations in this manner will help deliver a high-quality customer environment that supports the ridership and revenue target.

Ticket retailing technology is shifting away from face-to-face sales at stations towards mobile and self-service channels. This movement will only continue between now and the start of service and therefore the assumption that station staff will be providing customer assistance as well as selling tickets is appropriate.

At present, the model assumes flat levels of staffing across the two tours in each day. We believe that in practice an operator may choose to provide more staff during the morning peak at stations and less at other times of day. As in the case of dispatch staff, section 9 above, we would expect that in the first instance this would be achieved by re-allocating staff from the modeled establishment rather than adding additional resources. We have therefore not made a cost adjustment for this item.

6.2.2 TRAIN AND STATION CLEANING STAFF

The model assumptions for train and station cleaning staff are clearly set out in the documentation. The staff requirement for Level A and Level C stations appear appropriate while those for Level B stations are higher than might reasonably be expected. Without the benefit of station plans and details of the surfaces and finishes to be cleaned it is not possible to be definitive on this point but it is likely that a commercial operator will achieve savings in this area.

Modeled resources for train cleaning operate from terminal stations and rolling stock depots. The model assumes that stations where three or less trains are turned back into revenue service do not have any additional dedicated cleaning resources but rather complete this task with a mix of station and train staff.

This approach is possible and we would expect litter picking a train interior to fall within the normal duties of on-board staff. However, it is essential that toilets are cleaned during a turnaround and it is not reasonable to assume that customer service staff will clean train toilets as a turnaround activity. Therefore, some dedicated cleaning resource is required for each train that is turned at a station. On the assumption that trains will only be turned at Level A and Level B stations then station cleaning staff already assumed should be available to perform this task.

Given the fact that cleaning resources at Level B stations may be a little generous it is fair to assume at this stage that an operator could optimize the modeled station cleaning resources to deliver all the required tasks.

6.3 Uniforms, Vehicles, Supplies and Information Technology / Software

The model contains assumptions for: uniforms, vehicles, office supplies, cell phones and information technology / software. The unit rates applied have been derived from reasonable sources and appear appropriate.

However, we can find no mention in the model of other non-labor costs incurred at stations including: facilities management and routine maintenance. The cost of these items is material and therefore an adjustment to the modeled operating cost is required. An adjustment for cleaning materials at 10% of the labor costs has been made in the memo and a comment on facilities management and routine maintenance made in point 4 of section 4.3 of this report above.

7. POLICE AND SECURITY POSITIONS

7.1 Primary Drivers

The primary drivers are appropriate for this stage of modeling.

7.2 General Assumptions

The general assumptions are reasonable, subject to specific comments in this section on duties and in the Personnel Headcount section on numbers.

Duties identified in the General Assumptions cover those that would be expected for sworn and unsworn officers. There are however some specific facets of police and security work on railway systems that should be considered as the O&M model is developed:

- Crowd control operations are by nature irregular, often driven by special events, and labor intensive. They will require resources in excess of those routinely scheduled in the model as it stands. An adjustment to the model for this factor is not proposed at present as it would be reasonable to assume that the need for additional staff for crowd control duties would be funded from the incremental passenger revenue generated by the event.

- Police and security staff will be required to work in non-passenger areas of an operational railway, e.g. when patrolling lineside or attending fatalities on the track. To do this safely, regular training and certification will be required which will incur a cost. This is a point of detail that does not require a cost adjustment to the model at this time.

7.3 Personnel Headcount

The model provides sufficient police and security personnel to provide at least one member of staff is on duty at all times on a 24/7 basis. This is illustrated in the table below:

Table 18: Police and Security Personnel Headcount

Location	Sworn	Unsworn	Staff Hrs Available	Hours to Cover	Staff Coverage
Level A Station	6	12	720	168	4.3
Level B Station	3	7.5	420	168	2.5
Level C Station	3	7.5	420	168	2.5
Maintenance Facility	0	6	240	168	1.4

In practice, it would probably be prudent to reallocate resources from the Level C stations to the maintenance facilities which will have a greater need for routine security coverage to prevent theft and unauthorized access. European practice is to deploy peripatetic police and security resources across the majority of stations and only provide a fixed presence at the largest stations.

8. COMMERCIAL COSTS AND FUNCTIONS

Commercial costs have been modeled at a high-level and at this stage include marketing, call center, credit card and feeder bus costs. Given the level of development of these costs we have no comment at this stage. Clearly, as the model continues to develop the level of detail relating to these costs will increase.

No O&M costs have been included for the retail systems that will be required to sell tickets, manage yields and protect revenue. We fully appreciate that the systems deployed will be an operator led decision and that ticket retailing is going through a period of great change. However, it is certain that the operator will have to operate and maintain at a minimum:

- A back-end ticketing system
- Facilities to transmit and read electronic tickets
- Fixed and portable revenue protection equipment
- A yield management system

We have identified retail costs equivalent to 3.77% of revenue in the O&M Cost model covering call center charges, credit card commissions and station based staff. Our view is that the total cost of sales should be raised to 5% of revenue to cover items not currently identified in the O&M Cost model including: on-going system maintenance costs, data charges and ticket fulfilment. As a comparison, the UK third party retail commission rate for internet train ticket sales is currently 5% plus fulfilment fees while the station sales commission rate is 9%.

We also note that no allowance has been made in the O&M Cost model for: commission to third party ticket retailers, for selling tickets, or refunds / passenger compensation. These items should be taken into account as the retail strategy develops.

The Authority's position was that retail (fare selling) systems would be purchased as a capital item, and that O&M costs would be limited to supply of consumables (tickets) and maintenance of fare gates and vending machines. Our view is that a commercial train operator would want to procure its retailing system, including fare sales, as a service. The system would need to be regularly updated, to maintain compatibility with other systems including internet and smartphones. Revenue management software is still available, and will continue to evolve, as new ways are found to combine historic data and real time sales information. A single HSR operator would not have the specialist resources. That said, the Authority's revenue forecasts do not assume sophisticated market pricing, and so arguably it is not necessary to include the costs of this either. We accept that fare gates and station vending machines could be purchased as a capital item.

The Authority pointed to the Taiwan HSR system as one that had procured its fare collection system entirely as a capital item, and the Authority considered that it had a “yield management” system. Taiwan HSR has fixed tariff fares, although there are discounts of up to 35% for advance purchase and these are apparently quota-controlled. This is essentially where British rail pricing, and indeed US airline pricing technology was in 1990. UK rail operators and international and US airlines now use much more sophisticated revenue management systems to offer a much wider range of fares, with the cheapest tickets as little as 10% of the most expensive ticket. Often, cheap fares are available even up to the day of travel, but with restrictions for example requiring a round trip purchase, and travel on specified trains only. We expect that an operator of the California HSR system would do the same.

9. GENERAL ADMINISTRATION AND EXECUTIVE MANAGEMENT

9.1 Related Personnel

The O&M model uses the simple assumption that derives the G&A personnel headcount as 10% of the modeled workforce. For the size of the operation in question this results in a G&A establishment of 91. This top down approach produces a result which is of the right order but looking at the range of functions to be managed and the geographically distributed nature of the operation we believe that a higher G&A establishment will be required and an adjustment to the model has been made to raise the percentage used from 10% to 12.5%.

10. INSURANCE

The Authority stated that it is reviewing its budget for insurance with the assistance of a specialist consultant, and they are considering the impact of the railway’s safety features. We did not, therefore, review this value.

11. CONTINGENCY

The contingency includes an allocated element, related to staff certainty in the budgets they put forward and an unallocated element that is additional to the allocated contingency. The Authority benchmarked the total contingency against other high-speed railways’ variance in O&M costs as well as the Department of Transportation’s guidance, and in so doing conducted a Monte Carlo simulation of the probability of several cost over-run scenarios.

11.1 Allocated Contingency

The Authority describes a bottom up approach to setting contingency for each line item where by the staff who prepared the budget provided relative uncertainty levels for their estimates. These were then converted to contingency at levels scaled between 15 and 35%. This scale was selected with reference both to the Department of Transport’s suggested range of 20%-40% and with the variance to budget for O&M of several other high speed railways.

As an internal budgeting process, this approach seems appropriate at this stage for allocated contingency.

The allocated contingencies range from 16.25%-25%. The Authority recognizes in the Business Plan that these estimates are subject to biases in both directions- both over-confidence and unawareness of omissions that would lead to lower estimates and inclusion of costs that appear likely to be optimized as the project develops.

11.2 Unallocated Contingency

The Authority has applied an unallocated contingency of 5%, of O&M costs (excluding allocated contingency). based on consistency with assumptions in the Authority's capital and lifecycle cost estimates.

11.3 Observations

The sum of the allocated contingency and the unallocated contingency falls toward the middle of the Department of Transport range of 20%-40%.

Rather than double check the uncertainty of the individual line items or benchmark further the level of unallocated or total contingency, we looked at a very simple sensitivity to the potential variation in the revenue forecast compared to possible variation in the O&M. This is consistent with the context of this memo: to consider the O&M costs at steady state within a certain set of assumptions- and in comparison to the expected revenue.

In other contexts, the Authority may wish to review the level of contingency.

Coming closest to the costs themselves, the adjustments this memo has identified would add 6% to the steady state costs. If the Authority adopts these adjustments, it will, at some stage, want to consider whether it can reduce the allocated contingencies on the affected lines because of these additions, and whether it should allocate contingency to these adjustments.

Furthermore, in the context of a procurement exercise or a wider budgeting decision where the surplus funds will be apportioned to other uses, there may be pressures to set the contingency at a higher probability level. It would appear that a higher contingency could be supported given that the project is at an early stage: rolling stock not yet designed, service levels not set, commercial terms for early operator not yet known.

This decision on the probability level to attach to the contingency sits with the Authority and will need to be made in the context of the consequences of overspend or underspend, the degree of cost certainty and the view of the outturn of both the opportunities and the risks.

PFAL Project Finance Advisory Ltd. fcp

APPENDIX B – RIDERSHIP AND REVENUE MEMO

Project Finance Advisory Ltd.

MEMORANDUM

Date: February 13, 2017

To: Mr. Boris Lipkin
Deputy Director of Business
Analytics and Commercial Implementation
California High Speed Rail Authority
700 L Street
Sacramento, CA 95814

Re: HSR14-65 Memo on Ridership and Revenue for Valley to Valley Line of the California High-Speed Rail System

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In December of 2015, Project Finance Advisory Limited ("PFAL") was commissioned by the California High-Speed Rail Authority ("Authority") to provide an independent review and report of the detailed funding plans for the California High-Speed Rail System ("System") pursuant to California Streets and Highways Code 2704.08(d)(2). Through an initial review of public documents including the 2016 Business Plan and supporting reports, PFAL and the Authority determined a detailed review of the ridership and revenue for the Silicon Valley to Central Valley Line ("Valley to Valley Line") as defined in the 2016 Business Plan would be of value for future funding plans. PFAL and their subconsultant, First Class Partnerships Limited ("FCP"), performed the analysis and review under HSR14-65 Task Order 2, executed on June 16, 2016. FCP is a rail strategy advisory firm based in London, England with experience developing intercity and high-speed rail services that do not receive on-going government financial support, as is required for the California High-Speed Rail System.

This memo outlines the review methodology implemented by PFAL and FCP, the analysis performed by PFAL and FCP on the California High-Speed Rail Ridership and Revenue Model prepared by Cambridge Systematics, Inc. ("CS") for the Valley to Valley Line, and PFAL and FCP's findings and conclusions. The analysis described in this memo, if necessary, will assist in determining if the Valley to Valley Line can operate without subsidy.

We consider the CS forecasting model to be of good quality and can provide it with a clean bill of health in terms of its design and functionality. We have identified a number of areas where we consider the produced forecasts to be optimistic and also a number where we consider the forecasts to be pessimistic. We have also independently assessed the likely range of revenue outcomes.

We consider the Phase I forecasts to be significantly cautious; but for the Valley to Valley Line service we consider the forecasts to represent a reasonable central estimate. However, as is always the case with new rail lines, there is considerable uncertainty around the forecasts. Our low end revenue forecast (at the 90th percentile) is 42% lower than the central forecast prepared by CS, with our high end forecast (at the 10th percentile) being 47% above it. It is important to note that these estimates are based on the assumptions that were used by CS. If trains are faster or slower, more or less reliable, or priced lower or higher than assumed, the ridership and revenue forecasts will be different. Likewise the estimates are based on estimates of California population, employment and incomes, and assumptions as to the cost and characteristics of competing modes.

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1. REVIEW METHODOLOGY

CS, a specialist transportation-planning firm with offices across the US, developed the Authority's ridership and revenue forecasts. CS has built a "synthetic" travel forecasting model that estimates long-distance (to locations 50 or more miles from a traveler's home) travel by car, air, conventional rail ("CVR"), and, as appropriate, high-speed rail ("HSR") within the State of California. The model estimates long-distance trips made each day, the destinations of those trips, and the mode used based on households and their characteristics, employment, and the levels of service afforded by the different modes. We have concluded that this model is suitable for the purposes of forecasting future California high-speed rail ridership and revenue.

Our review of the CS model and its forecasts was based on:

- An in-depth review of the model documentation, including:
    - California High-speed Rail Ridership and Revenue Model Business Plan Model- Version 3 Model documentation;
    - CHSRA Ridership and Revenue Forecasting 2016 Business Plan Technical Supporting Document;
    - Technical memorandum; TO: Jeff Morales, Executive Director, California High Speed Rail Authority; FROM: Frank S. Koppelman, Chair, Ridership Technical Advisory Panel (RTAP); Date: December 16, 2015; RE: Review of progress on revenue and ridership forecasting;
    - California Department of Transportation 2010-2012 California Household Travel Survey; Final Report Appendix;
    - December 16, 2015 Technical Memorandum – Review of Progress on Ridership and Revenue Forecasting; and
    - February 8, 2016 Response to December 16, 2015 Technical Memorandum – Review of Progress on Ridership and Revenue Forecasting
- Our extensive understanding of multi-modal forecasting models, especially for HSR projects, and the associated markets includes, but not limited to:
    - Eurostar (London – Paris/Brussels High-Speed Rail line);
    - UK High Speed 2 ("HS2")
    - France: Paris – Lyon/Marseilles High-Speed Rail ("LGV Sud-Est"); LGV Bordeaux – Toulouse/ Spanish Border;
    - Australia: Sydney – Canberra High-Speed Rail.

Our review covered:

- Model construction and development; i.e. is the structure of the model appropriate for the purpose it is being used? Did the development process lead to appropriate enhancements being made to the model?
- The assumptions underpinning the model; i.e. where parameter values have been estimated using statistical techniques and/or calibrated to observed data, were appropriate and industry standard practices followed? Where it was not possible to estimate or calibrate parameter values, have appropriate methodologies been used to derive values? Are the values reasonable compared to those seen in similar circumstances elsewhere?
- The outputs from the model, including how sensitive the model was to various inputs; i.e. are elasticities to fare and time and values of times reasonable when compared to those observed elsewhere? Are the forecast mode shares and levels of demand reasonable when compared to those observed elsewhere with HSR?
- Model validation; i.e. does the model accurately reproduce current travel patterns? Does it forecast any observed changes in demand that result from previous changes in characteristics of modes that are modeled?

In addition to considering what the model included, we reviewed documentation provided by CS and the Authority for any potential omissions from the model which we would typically expect to see included in international high-speed rail models.

We initially reviewed the published documentation (as detailed above). While the documentation was thorough and detailed, due to the depth of our review, we compiled a list of questions and requests for additional analysis and model tests.

Our questions were broken into ten categories for further clarification:

- Source Data
- Stated Preference Research
- Buses
- Market Segmentation
- Mode Constants
- Induced Demand
- Validation
- Load Factors
- Risk Analysis
- Other

The Authority, with the support of CS, was responsive to our requests and provided the necessary answers, clarifications or, in a few cases, explanations why responses could not be provided to the detailed requests. In cases where responses were not provided it was because, we understand, information was not available (such as from external sources). This has not prevented us from completing the review and reaching the conclusions described in this document.

We adopted an iterative process to address our clarification requests. We produced our initial questions based on a sample of the published documentation in order to get the process started rapidly; following the Authority response to this, a fuller list of questions based on a review of all available material was then submitted. In addition to the written responses, we agreed with the Authority that teleconferences[1] would assist in understanding of both the questions and their responses. The teleconferences allowed the reasoning behind our questions to be explained and the Authority's responses to be tailored to the most important issues.

In total, there were three rounds of questions and responses, and two teleconferences.

At this point, PFAL and FCP had developed a considerable understanding of the CS model and how it behaved. To ensure we fully understood the responses provided to our various questions, PFAL and FCP developed a document to summarize our understanding. This was then iterated with the Authority and CS to ensure we correctly understood what had been done. After receiving factual corrections from the Authority, we produced an agreed statement of facts (see Appendix A).

Following the finalization of the statement of facts, we identified a set of ten areas that required further clarification. These points had potential to impact our view of the forecast upwards, downwards or by adding uncertainty either up or down. While the process of written questions and answers supplemented by teleconferences had been effective, it was agreed that a face-to-face meeting would be more productive and the most efficient way to proceed with exchanging ideas on the remaining points. This took place and led to a considerable degree of shared understanding of the areas for further investigation and their possible impact.

At the end of the meeting, three areas were still open that required further analysis. The remaining areas of inquiry were closed out during the course of the meeting. The Authority and the review team both undertook further analysis and a partial resolution of these three issues.

[1] Teleconferences were used at this stage in preference to face-to-face meetings due to the international nature of the review team.

Throughout the process, the review team was careful to remain independent while listening to information provided from the Authority and CS. The following sections represent the review team's independent analysis and conclusions of the Model based off the methodology described in this section.

2. CS MODEL ANALYSIS

Our review of the CS Model covered the CS model construction, CS model assumptions, CS model outputs and CS model validation. Though the CS model construction applies to the overall System, our review of the assumptions, outputs and validation focused on the ridership and revenue numbers for the Valley to Valley Line as defined in the 2016 Business Plan.

2.1 Model Construction

The forecasting model used by CS is derived from the classic four stage model commonly used in transportation planning, but with some important additions. The four stage model was originally developed in the context of urban transportation planning and represents the choices between:

- How often to travel (including whether to travel at all) (generation)
- Where to travel to (distribution)
- Which mode to use (typically auto or transit) (mode choice)
- Which route to use (assignment).

In the context of long distance travel and high-speed rail in particular, it is necessary to adjust the traditional four-step model. Model adjustments and enhancements included in the CS model are as follows:

- Main modes are different than regional model main modes (i.e. CS model includes choice of travel between auto, air, conventional rail, and HSR)
- Access/egress mode choice component was added
- Only long-distance trips are modeled
- The entire model system works as a nested logit model, with full upward model integrity through the use of logsums at each model step
- Trip frequency model is unique in that it is a random utility maximization model rather than using simple trip rates that may or may not vary over demographic segments.

In principle, the enhanced model structure is appropriate and similar to what we have seen for other HSR projects worldwide. It is suitable for the purpose of forecasting high-speed rail ridership and revenue. We note that CS correctly sought to estimate a nested model for the mode choice element, where the choice between rail modes is often closer than between other modes, and indeed the choice between all public transportation modes can be closer than that between these modes and auto. We discuss their ability to find such a nested model and the estimated parameter values in the next section, 2.2 CS Model Assumptions.

We noted one deviation regarding the model structure from international HSR models. That is the omission of long distance bus as a main mode. In Europe, long distance bus is not generally considered a competitor to HSR as it takes significantly longer than conventional rail and has only a minor share of long distance market. In the UK, long distance bus typically have 10% of the demand of conventional rail, and in many other European countries where it is regulated and not intended to compete with rail, it is significantly lower. However, when members of the study team undertook HSR forecasts in Australia, we found that long distance bus was as fast as, and had a higher market share than conventional rail; there we found it necessary to include long distance bus in the mode choice. We believe that it would be better to do so in California as well, as while long distance bus is a minority mode, it is comparable in its importance (market size) to conventional rail.

CS has effectively removed all current long distance bus trips from the dataset they used for both the model estimation and for forecasting. This means that there is no ability within the model for HSR to capture ridership from long distance bus. This approach is inherently conservative. However, there is also a risk that it may have implications for the estimation of other model parameters. Omitting significant data from model estimation may result in other factors being estimated as having influenced demand, whereas it was the omitted factor (in this case the presence of bus competition); we cannot say whether this risk biases forecasts up or down (if at all). We discuss the implications of this further in Section 3 (Conclusions).

2.2 CS Model Assumptions

CS has followed a sophisticated and, in principle, appropriate process to derive the model parameters. As with all models, assumptions and approximations needed to be made, and those assumptions are described below.

The main data source used was the California Statewide Household Travel Survey (“CSHTS”) (2012/13). As was expected and typical for similar types of travel surveys, only a minority of respondents had made a long distance (greater than 50 miles) journey on the day being surveyed (1,965 valid long distance households responses). A further 12,183 households responded to the Long-Distance Travel recall part of the survey which asked for long distance journeys made over a longer period. A total of 38,787 in-scope trips were found valid from these sources.

This is a good size sample in line with other travel demand surveys, but there must always be scrutiny over how random the sample is since there is non-response inherent in all surveys of this type. For example, frequent travelers may be less likely to participate, it may be difficult to recruit young, single people, etc. The CSHTS addresses some of the non-response through the use of a quota-based sample design and best practices regarding call-backs for recruiting and data collection. Finally, as is stated in the CS report, the model only forecasts travel by residents of California, as these were the only people surveyed. There will be a small proportion of travel made by non-Californians and indeed non-USA residents excluded from the forecasts.

Our experience in other HSR studies is that most have sought to contact people in the course of a long distance trip to obtain accurate data on current travel patterns at the aggregate level and to understand behavioral characteristics through stated preference (“SP”) surveys. This approach is often used to develop a different type of travel forecasting model (e.g. a “diversion” model from existing modes) than the synthetic model developed by CS. CS performed intercept surveys of long distance travelers as part of their collection of a 2013-2014 revealed preference (“RP”)/SP survey. Travelers were intercepted at airports and on conventional rail services. In addition, a number of respondents from the CSHTS who had made recent long distance trips by auto were surveyed. The RP/SP survey was not used to develop current travel patterns but, rather, to investigate travelers’ willingness to change from their RP mode for the trip to a different mode based on a number of SP “experiments.” Each of the experiments presented different travel times, costs, service frequencies, and reliabilities for three travel modes for the traveler’s observed trip – the traveler’s chosen mode, HSR, and a third mode – and asked the traveler to indicate which mode they would select for the observed trip given the different travel characteristics of the three modes.

The RP/SP information was used in the development of the synthetic model. The RP data provided additional observations of actual mode choice for long distance trips. The SP data provided information on the selection of a new mode given realistic service level characteristics for different mode alternatives for the RP trip reported by the respondent. Best practices were used to ensure that the SP data were properly represented in the estimation of the synthetic mode choice models. This resulted in mode choice models that reasonably represent traveler mode choice behavior.

The one concern we have with this approach is that the RP data relies entirely on surveys; there is no count data of actual usage of air, CVR and auto on a flow basis. We understand that CS were unable to obtain such data.

However, in our view the RP/SP survey was conducted in a professional manner. The HSR service described to respondents in most cases is one that would operate between the stations they would expect to use if travelling by train. As such it should give a reasonable assessment of how attractive HSR would be with such a service. This is the case for the Phase 1 service for most travelers, as defined in the 2016 Business Plan, but may not be for a significant number in the context of the Valley to Valley Line service where travelers to/from the Southern California area have long access/egress journeys to Bakersfield (or north thereof). While the access and egress times to HSR exceeded travel time on HSR by as much as a factor of three in some of the SP experiments, the maximum access time used in the experiments was 85 minutes and the maximum egress time was 75 minutes; the maximum of the combined times was 150 minutes. Based on the SP (and other sources) the model includes a perceived benefit to travelling by HSR (compared to CVR) over and above the journey time savings. However, there may be a question regarding whether the model sufficiently captures the impact on this perceived benefit of the long access/egress between southern California and the Bakersfield HSR station. Potential impacts to ridership are discussed in Section 3.

The Version 3 model (used for the 2016 Business Plan) includes an approach that compensates at least in part for the impact of long access/egress journeys. The model includes coefficients (estimated from the observed data combined with the SP data) that penalize access and egress as those times increase in comparison to the overall journey length. The penalty coefficient for access and egress by auto modes is much larger than the penalty coefficient for non-auto modes. Since the penalty coefficients are applied to the ratio of the access (or egress) time (in minutes) to the total trip distance (in miles), provided the ratio exceeds 0.2, the smaller magnitude of the transit penalty coefficient will be offset in part by transit access and egress times that will generally be greater than auto access and egress times. Furthermore, due to data availability, CS found it necessary to assume the same penalty for access and egress (albeit a different value was calibrated for the absolute element to reflect that auto at egress is car rental, whereas for access it is own car).

In principle, this approach is reasonable and experience elsewhere suggests that such penalization is often required to ensure the model reasonably reflects observed behavior. However, we note that the estimated parameters do have a significant impact on the forecasts for Valley to Valley Line. Potential impacts to ridership are discussed in Section 3.

As stated earlier, the estimated model is a nested logit model as would be expected. However, the nesting parameter is very close to 1, resulting in an effective model with little difference from a multinomial model. This results in HSR capturing its demand from each of the existing modes pro rata to their current shares of the market (for each origin/ destination pair). This is unusual in an international HSR model. International experience suggests existing rail users are most likely to switch, followed by other public transportation users (bus or air) with auto users being least likely to switch since many auto users are effectively captive to the mode due to either the amount of baggage they have or the need for their auto at the destination. CS agreed that the size of the nesting parameter was not as expected, but it gave the best fit to the data, and they preferred to be guided by the data than introduce assumptions not based on evidence.

The model includes four-market segmentation: Business; Commute; Recreation; and Other. For the mode choice model estimation, CS combined the business and commute segments, and the recreation and other segments, resulting in the same parameter values for these pairs of segments with the exceptions of the cost coefficients for the business and commute segments and the mode specific constants for each of the segments. This does not cause us any major concerns. However, we believe the average fare used for all four segments for each of air and HSR is not realistic for current air travel markets, although it might be for CVR. An average fare assumption may not be representative in the future for HSR assuming the operator seeks to optimize revenue. We recognize that data on actual fares paid by segment are not available (although market research could have identified them). At our request, CS re-estimated the models with alternative fares assumptions which were approximate but, in our view, more realistic. This resulted in very little change in the cost coefficient of the recreation/other model, but did make a modest impact on the cost coefficient of the business/commute model in the direction that we would have expected. Overall, these changes would have a minor impact on the forecasts as outlined in Section 3.

The mode constants for CVR and air are calculated to recreate the current mode shares. However, they have an alternative interpretation in that they represent an inherent preference (or opposite) for the mode in question when all the modeled elements have been taken into account. The modeled elements are:

- Fare or out-of-pocket cost
- Journey time
- Headway for air, CVR and HSR
- Reliability for air, CVR and HSR.

The mode constants also take on different values according to income and certain other attributes.

The magnitude of some of the mode constants is very large when put into equivalent minutes compared to international experience. In part, this may be due to different model constructs with some models allowing elements of captivity (especially to auto). Nevertheless, we considered the large mode constants worthy of further investigation. The mode constant for HSR clearly cannot be calculated from observed mode shares as HSR has zero mode share today. Two approaches were used, both of which are reasonable:

- The constant was calculated using the SP survey and then adjusting the air and CVR constants according to the information derived from the SP survey; this was called the offset approach.
- The air and CVR constants were averaged as they were considered an intermediate mode.

The constant eventually used was the average of the two derived constants above. Due to the large constants for air and CVR (and also relative to each other) the uncertainty in the HSR constant is also large as either approach could be justified. CS recognizes this in their risk analysis where 83% of the overall risk is derived from the uncertainty in the HSR mode constant. However, we are not opposed to the CS approach to deriving the HSR constant. In a perfect modeling world, uncertainty in the HSR constant would be lower, but their approach to deriving the HSR constant is fundamentally sound.

In many other long-distance HSR models, trip generation and trip distribution are not modeled explicitly. Instead, existing origin-destination trips along the corridor are simply factored up based on sociodemographic estimates in the forecast year. Induced demand is forecasted as a separate add-on within the model. The CS model, on the other hand, explicitly estimates the number of intra-California long-distance trips made by each household (trip generation) and then estimates where these trips are going (trip distribution). These estimates are based not only on sociodemographic and land-use characteristics of each zone, but also on the accessibility (ease of traveling) between zones. With the introduction of HSR, the accessibility of traveling between zones that are connected by HSR is increased, thus increasing the desirability to make trips between these zones. This induced demand due to the introduction of HSR is directly estimated within the CS model. However, the CS forecasted induced demand is much lower than is estimated by other long-distance HSR models and is lower than has been observed when a major enhancement is made to rail services (such as HSR).

It is also important to note that the model does not take into account any generation of demand due to changes in development around stations or existing development converted to alternative uses. It might be expected that a fast link to the San Francisco Bay Area would cause some businesses and people to relocate to offices and houses near to the stations, and thus generate additional rail travel on HSR. This can be expected to happen even without supportive land use policies. However, we should state that it is common in HSR models to exclude such induced ridership because it is very difficult to quantify; nevertheless it can be substantial.

2.3 CS Model Outputs

The previous section considered the assumptions underpinning the CS model such as parameter values. We start this section by considering the inputs to the model such as fares/costs, travel times, and reliability. Some of these are policy variables: the Authority (or operator) can choose to set fares as it wishes, others are dependent on technology or investment (train journey speeds and hence times, etc.).

Most of the inputs of this nature in the CS model seem reasonable. We have already discussed HSR fares; we would expect (and the authority has indicated) that a commercial operator would charge differential fares targeted at different markets – the precise mechanism to achieve this is unimportant at this stage but could involve differential pricing (similar to airlines) by time of day, cheaper advance purchase fares, etc. For practical reasons and consistency with fare assumptions used for air and CVR, the model uses a single average HSR fare for each station to station pair. Since the 2012 Business Plan, ridership and revenue forecasts have been based on an assumption that the HSR average fare for interchanges between Los Angeles and San Francisco should be 83 percent of average airfares between Los Angeles and San Francisco airports. The fare model developed for the 2012 Business Plan has been used for the 2014 and 2016 Business Plans. The fare model implements the HSR fare policy by combining a fixed boarding fare with a distance-based, station to station fare.

We have not checked the journey time assumptions as they seem reasonable. Reliability targets also seem reasonable; indeed the assumed reliability is modest even compared to what is achieved in Europe, let alone Japan which measures lateness in terms of seconds rather than minutes.

We now turn to considering the outputs from the model. We first look at how HSR captures demand from other modes. Table 1 shows the source of HSR demand for each of seven major markets in the Valley to Valley Line based off the CS model.

Table 1: Sources of HSR Demand – Valley to Valley Line (derived from CS response to Q D3.1)

MARKET PAIR	HSR DEMAND (ANNUAL RIDERSHIP 2025 - MILLIONS)	FROM AUTO	FROM AIR	FROM CVR	INDUCED
BAY AREA (MTC) - SAN JOAQUIN VALLEY (SJV)	**2.227**	**90.4%**	**1.4%**	**2.6%**	**5.6%**
BAY AREA (MTC) - SOUTHERN CALIFORNIA (SCAG)	**1.476**	**51.9%**	**42.3%**	**0.5%**	**5.3%**
BAY AREA (MTC) - SAN DIEGO (SANDAG)	**0.115**	**41.7%**	**53.0%**	**0.0%**	**5.2%**
SACRAMENTO (SACOG) - SAN JOAQUIN VALLEY (SJV)	**0.151**	**95.1%**	**2.4%**	**4.1%**	**-1.6%**
SACRAMENTO (SACOG) - SOUTHERN CALIFORNIA (SCAG)	**0.173**	**56.1%**	**39.3%**	**0.6%**	**4.0%**
SAN JOAQUIN VALLEY (SJV) - SOUTHERN CALIFORNIA (SCAG)	**0.605**	**87.9%**	**6.9%**	**3.1%**	**2.0%**
SAN JOAQUIN VALLEY (SJV) - SAN DIEGO (SANDAG)	**0.090**	**81.1%**	**13.3%**	**1.1%**	**4.4%**

It can be seen that the majority of ridership comes from auto, with air an important source on the longer distance flows. The dominance of auto as a source of demand is unusual for HSR and reflects the current dominance of automobiles for travel within California. As noted above, existing intercity bus traffic is excluded from the CS analysis. Induced demand is below 6% in all market pairs (and in one case slightly negative demand). This is very low; induced demand on new HSR systems is typically in the range of 20% to 50% of total trips.

Table 2 shows mode shares once HSR is in place are below; again figures are for Valley to Valley Line scenario and based off the CS Model.

Table 2: Mode Shares – Valley to Valley Line (derived from CS response to Q D3.1)

MARKET PAIR	HSR	AUTO	AIR	CVR
BAY AREA (MTC) - SAN JOAQUIN VALLEY (SJV)	5.2%	93.1%	0.6%	1.2%
BAY AREA (MTC) - SOUTHERN CALIFORNIA (SCAG)	7.0%	64.5%	28.2%	0.3%
BAY AREA (MTC) - SAN DIEGO (SANDAG)	3.2%	52.1%	44.6%	0.2%
SACRAMENTO (SACOG) - SAN JOAQUIN VALLEY (SJV)	0.9%	98.0%	0.2%	1.0%
SACRAMENTO (SACOG) - SOUTHERN CALIFORNIA (SCAG)	2.4%	70.9%	26.4%	0.3%
SAN JOAQUIN VALLEY (SJV) - SOUTHERN CALIFORNIA (SCAG)	1.8%	94.2%	1.4%	2.7%
SAN JOAQUIN VALLEY (SJV) - SAN DIEGO (SANDAG)	2.6%	90.3%	5.7%	1.3%

Generally, these predicted mode shares appear reasonable. We would make the following comments:

- Forecasts for HSR capture only 7% of the MTC - SCAG market. This is because there is intensive air competition, in the Valley to Valley Line, and long access journey at both ends;
- Forecasts for HSR capture only 5.2% of MTC – SJV trips, which seems a low market share given that Valley to Valley Line will offer a single ride HSR service between the two regions. The reason is there will be many trips between the two regions that are relatively short and not served directly by HSR, for example Merced – Oakland or Los Banos – Gilroy. We would expect that the HSR share of trips between Bakersfield, Fresno, and San Jose would be much higher, about 20%.

Table 3 compares the HSR shares for the Valley to Valley Line with those achieved in the Phase 1 scenario, when there is a direct HSR service between San Francisco and Los Angeles.

Table 3: HSR Mode Shares – Valley to Valley Line compared with Phase 1(HSR Share Phase 1 derived from Business Plan Table 6.3)

MARKET PAIR	HSR SHARE VALLEY TO VALLEY LINE	HSR SHARE PHASE 1
BAY AREA (MTC) - SAN JOAQUIN VALLEY (SJV)	5.2%	9.3%
BAY AREA (MTC) - SOUTHERN CALIFORNIA (SCAG)	7.0%	27.9%
BAY AREA (MTC) - SAN DIEGO (SANDAG)	3.2%	18.9%
SACRAMENTO (SACOG) - SAN JOAQUIN VALLEY (SJV)	0.9%	1.6%
SACRAMENTO (SACOG) - SOUTHERN CALIFORNIA (SCAG)	2.4%	11.8%

SAN JOAQUIN VALLEY (SJV) - SOUTHERN CALIFORNIA (SCAG)	1.8%	15.5%
SAN JOAQUIN VALLEY (SJV) - SAN DIEGO (SANDAG)	2.6%	13.6%

The impact of removing the need for long access to Los Angeles and San Diego, and consequent reduction in journey time and cost, is noticeable and plausible.

Our overall comments on the forecasts are:

- While the sensitivity to fare and cost appear reasonable, the sensitivity to time on HSR (and other main modes) is significantly below that seen in overseas markets;
- However, when access and egress modes are taken into account the implied overall sensitivity to time increases to a plausible level;
- It is important to note that the treatment of long access and egress has a major impact on the ridership forecasts for Valley to Valley Line; CS introduced this in the model used for the 2016 Business Plan, understanding that the available data was limited, and hence the robustness of the estimates of this element of the model is weaker than of the core of the model.

2.4 CS Model Validation

CS undertook several approaches to validation:

- CS compared the model outputs with high level summaries of the expanded (to represent all residents of California) CSHTS data. The comparison statistics were for model results not directly impacted by the model calibration.
- CS compared 2010 model outputs to independently collected CVR ridership data.
- CS produced a year 2000 backcast, comparing model results to region to region long distance trips summarized from the 2001-2002 CSHTS, observed air travel based on the FAA's 10 percent ticket sample data, and CVR ridership reported by operators.
- CS performed sensitivity tests on the model by assuming the Phase 1 HSR system was in place for 2010 and for the same system but assuming Northeast Corridor-like (NEC-like) rail travel times and fares.
- CS reviewed overall HSR ridership elasticities with respect to HSR costs, travel times, headways, and reliability for reasonableness.

In general, the results of the validation and sensitivity tests were reasonable. The initial 2000 backcast produced a poor match for air travel, but as explained in CS' February 8, 2016 Response to December 16, 2016 Technical Memorandum, the input data and some input assumptions were flawed. There have been many changes to air travel in the last 16 years, notably considerably longer effective check-in times due to security requirements, so reasonable assumptions had to be made. After correcting the air levels of service and adjusting assumptions regarding waiting times at airports due to increased security requirements, the air backcast was much more reasonable. However, with other possible assumptions, the backcast might remain poor, and we cannot draw strong conclusions from this element of validation.

Comparisons of modeled CVR segment volumes (i.e. CVR ridership between stations) matched the reported ridership reasonably for both 2010 and 2000, especially for the Amtrak San Joaquin and Capitol Corridor routes. However, as only link volumes were available on trains (ie numbers of passengers on-board train at particular location) and not point to point flows, and many of these are local passengers, again we cannot draw strong conclusions from this element of the validation. The NEC-like service sensitivity test showed that HSR ridership forecasts are sensitive to input assumptions. Finally, the elasticity to cost in the model appears to be reasonable, but that to time is low when compared to experience elsewhere.

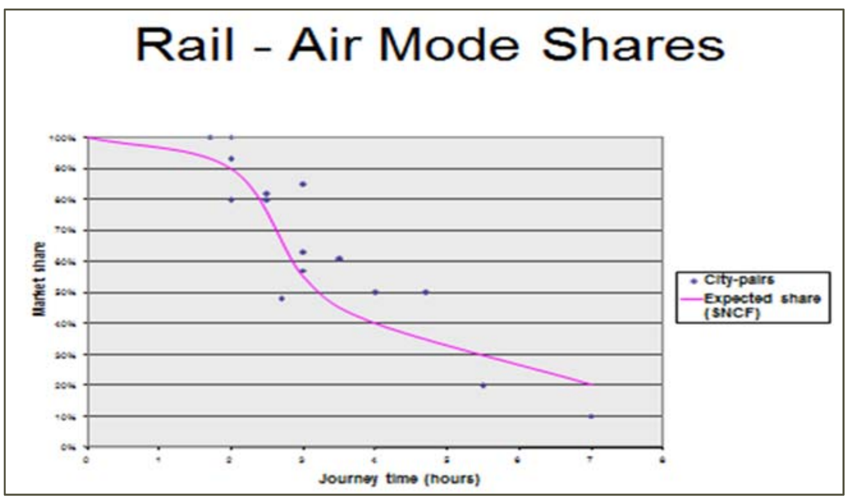
Other benchmark studies were conducted when possible as part of the validation process. For example, there is a long history of bus connections to rail services in California available for benchmarking. In 2014, the San Joaquin Amtrak service had approximately 1.2 million riders. Of those, approximately 400,000 used the thruway buses from Bakersfield to connect to/from destinations in Southern California. Additionally, over 400,000 used the bus connections at Emeryville, Stockton, Hanford, and Merced. Thus, out of a total of about 2.4 million access/egress trips to the San Joaquin Amtrak service, about a third used the Thruway buses to get to/from the rail system. HSR rail-bus connections are not forecast to be as high of a percentage as the Thruway-Amtrak rail connections. Nevertheless, the San Joaquin results are empirical evidence for California residents' willingness to make those kinds of rail-bus connections when they are dedicated and of high quality.

No benchmarking has been done against experience outside California. In all other HSR studies FCP has been involved in, the results have been compared against experience elsewhere in the world. Such benchmarking would help ask and determine:

- Are mode shares comparable?
- Is projected ridership growth comparable with observed experience?
- Are model elasticities (e.g. to fare and travel time) in line with expectations?
- What level of induced demand has been experienced? (This is particularly difficult to identify through surveys)

The Authority has explained that it considers the Californian market to be unique and unlike any other HSR; hence benchmarking against international systems would not yield substantive validations. We acknowledge that California is different and we would not expect the same experience as elsewhere. For example, we would expect higher auto shares in California than in Europe both with and without HSR. However, we do not accept that nothing can be learned. There is a well-known graph demonstrating the relationship between rail/ air mode share and rail journey time, reproduced below.

Figure 1: Rail – Air Mode Shares of selected HSR corridors



Although the majority of observations from which the curve is derived are from Europe, a brief examination of public US Northeast Corridor data from Amtrak shows that they fall reasonably on the graph (slightly below the rail share of the expected share line), which fits with the high expectation of air travel in USA. This demonstrates that at least the North East Corridor is not that different from other international experience. Every rail market has unique characteristics; while California currently has low intercity rail ridership, the San Joaquin and Pacific Surfliner do already attract significant traffic. The Bay Area and Los Angeles basin actually have similar average densities to conurbations in Europe that are connected with HSR, and both now have extensive rail transit systems. European cities also have freeway systems and high car ownership. Our view is that California is not such an “outlier” as to make benchmarking meaningless.

A further validation we would have liked to see is with observed data based on actual carryings between origins and destinations (station to station) rather than against observed segment volumes between stations. We would expect Amtrak to have records of how many tickets are sold on an origin to destination basis, which could be used for validation. A comparison to such information could reinforce the validation against segment volumes already performed by CS.

Our conclusion on this point is that the extent of validation undertaken has been limited by available data and could be enhanced by further benchmarking to other rail systems in the US and abroad where high speed rail is more developed. The validation that has been undertaken has confirmed that the CS model results are reasonable.

3. CONCLUSIONS

3.1 Categorization

The objective of our assignment was to determine whether the HSR service ridership and revenue forecast is reasonable. This assessment will later be used by our team to form an opinion on whether or not the Authority can operate without a subsidy. To do this, we need to understand the forecasts of revenues and the operating costs. We need to know both the best central forecast of these elements and the range of uncertainty.

We have made our assessment of the central forecast and the range of uncertainty. We must state that this is not an exact science, but involves judgement based on our considerable experience of forecasting HSR (and other rail and transportation schemes and services) in many different contexts, some, but not all, of which were implemented and financed. We have sought to be as objective as possible in our judgement, basing it on as much evidence as we could gather, and listening carefully to the opinion and analysis of the model developers. The opinion below is our independent view as to an outcome and range to be considered when our team will view the ridership numbers when analyzing the Authority’s ability to operate without subsidy. The numbers below are in no way intended to replace or supplant the work performed by CS.

We considered the forecasts made by CS and identified a number of areas where we considered that alternative assumptions or forecasts could or should be made. These were categorized as one of:

- General – that is areas that create uncertainty in the forecasts but no clear bias as to the direction of uncertainty;
- Downside risk – that is we consider that for this reason the forecasts are most likely overestimates;
- Upside potential – that is we consider that for this reason the forecasts are most likely underestimates.

3.2 General

The first general area we consider is the mode constant for HSR as similarly identified by CS. This risk contributed 83% of the overall risk in CS risk analysis. We agree that this is an important risk area and the most influential on the modeled results. CS took an extreme view on the upper and lower bound of this risk; provided the forecasts are adjusted to take account of the other factors (as detailed below), we believe that evidence from other HSR means that this range can be reduced. Rather than calculate the risk based on a mathematical model, we prefer, in this context, to consider the outcome of other HSR and achieved forecasts, mode shares, etc. and hence derive a realistic assessment of the likely range.

We discussed in Section 2.2 the survey data underpinning the model is a risk area. All survey data brings some risk due to the potential for bias in the sampling. The RP data underpinning the model relies entirely on surveys; there is no count data of actual usage of air, CVR and auto on a flow basis. This is not ideal and we therefore have included risk from this area.

While the results of validation that was undertaken indicates the model is performing well, additional validation can be performed to provide even greater confidence in the forecasts. This was discussed in Section 2.4.

A risk not previously discussed is that of the treatment of car access and egress. Car access is mainly park and ride, although there is also some drop off and taxi. Car egress is a combination of taxi, car rental and some pick up. The model treats these with the same parameter values (albeit different costs and different mode constants); given the very different nature of park and drive (the dominant choice for access) from those available for egress, this must be questionable and a risk area.

3.3 Downside Risk

We have a concern that the estimated sensitivity to time on the main mode in the model is low compared to international models. While this is compensated on average by the high value for some long access modes (notably auto), it may be distorting the forecasts. It may be that Californians, on average, do have a low value of time, but we would not expect this given wage levels. The impact on the forecasts is not easy to assess, as the mode constant for HSR will compensate for any potential error in the sensitivity to time. However, this mode constant is derived in part from the SP survey, which assumed a through HSR journey comparable to that delivered in Phase 1.

We therefore do not consider this issue to represent a downside risk in the Phase 1 forecasts. However, it is a risk for the Valley to Valley Line forecasts, because there are some significantly longer journey times. The impact of these longer journey times may not be fully reflected in the forecasts if the sensitivity to time is too low. We therefore believe that, for this reason, the forecasts for Valley to Valley Line may be too high in the markets affected by long journey times. About one-third of Valley to Valley Line ridership and revenues is between MTC/ SACOG and between SCAG/ SANDAG, with journey times typically in excess of 5 hours.

Our second downside risk relates to the long access and egress journeys. While the penalty on auto access/egress at long travel times is high, we are concerned that the penalty on long distance access and egress travel time by transit is too low; we are also concerned that there is no similar penalty associated with access or egress trips that are below the threshold of 0.2 times the road distance. In addition, the lack of observed data at very long access and egress travel times, results in a high degree of uncertainty regarding the magnitude of this penalty variable. This concern mainly affects the flows between MTC/SACOG and SCAG/SANDAG, which generate about one third of HSR ridership and revenue in the Valley to Valley Line scenario. We do however note that, while these markets generate a substantial share of HSR ridership, CS is forecasting only a small share of the total travel will be made by HSR, with the vast majority of trips between these markets continuing to be made by auto or air.

3.4 Upside Potential

We have identified greater upside potential; in most cases, they affect all scenarios equally.

We discussed the use of a single fare by origin/destination pair for all market segments in Section 2.2. We consider that the omission of the air fare differential results in a small downside risk, but this is more than compensated by an upside potential for the omission of market fares on HSR.

Omitting current users of Intercity buses from the model dataset will have added some risk to the forecasts, but the biggest impact is that such passengers are assumed all to remain with bus and none to transfer to HSR – this constitutes upside potential. Experience in Europe is that substantial share of intercity bus passengers will switch to HSR, if competitive fares are offered.

The omission of non-Californians from the forecasts is clearly an upside potential as identified by CS. Certainly some tourists will use HSR, even in the Valley to Valley Line. There will also be trips made by people from outside California using HSR for business, leisure, and Visiting Friends and Relatives ("VFR").

The assumption that there is no change in land use/ development as a result of HSR is an upside potential, even assuming no actual intensification of land development. Existing housing and offices can (and would be expected to) be occupied in the future by those more likely to be interested in HSR than current occupiers.

The level of induced demand in the model is low by comparison with observed HSR elsewhere.

3.5 Quantifying the Risks and Potential – Approach

It is common in project appraisal to undertake a Monte Carlo risk assessment using software such as @Risk. This utilizes statistical properties to calculate the overall risk from a large number of inputs. The danger with such analysis is that it is not easy to identify what is causing the risk and hence which areas should be focused on to reduce risk. We have taken a more transparent approach.

We have identified nine factors from those discussed above that can be considered independent of each other – i.e. statistically uncorrelated. In doing this, we combined the survey data with lack of validation as the latter (i.e. validation) can be considered a measure of the error in data. We also combined the issue of time sensitivity with the treatment of long access journey as these two mainly relate to similar groups of travelers (i.e. MTC/SACOG to SCAG/SANDAG trips).

For each factor we assessed the central impact on the forecasts separately for Phase 1, Valley to Valley Extended and Valley to Valley Line. We then estimated a (symmetric) range around this central forecast that represents approximately the 90% probability due to that factor. Both these figures were based on our professional judgment weighing the evidence and informed by further analysis and model sensitivities undertaken by CS, observed ridership and mode shares of HSR elsewhere, and our own analysis of how different model parameters might change the forecasts.

To calculate the overall risk we combined the individual risks in the standard statistical method for calculating the error of a combination of independent factors; that is we take the square of each individual range (as a percentage), sum them, and then take the square root.

3.6 The Quantified Risk and Potential

Table 4 sets out our estimates for each factor for each of Phase 1, Valley to Valley Extended and Valley to Valley Line, along with the overall risks and range. We provide brief comments explain the figures estimated.

Table 4: Quantification of Risk and Upside Potential

	IMPACT ON CENTRAL FORECAST PHASE 1	IMPACT ON CENTRAL FORECAST VALLEY TO VALLEY EXTENDED	IMPACT ON CENTRAL FORECAST VALLEY TO VALLEY LINE	RANGE	COMMENT
MODE CONSTANT FOR HSR	1 (neutral)	1	1	±25%	This risk identified by CS (with larger range)
SURVEY AND VALIDATION	1 (neutral)	1	1	±20%	Mainly based on observed ridership elsewhere
FARES	1.05 (upside)	1.05	1.05	±10%	-5% for air fares; +10% for HSR fares
INTERCITY BUS	1.05 (upside)	1.05	1.05	±5%	Market not included in CS model up to 10% increase in ridership
NON CALIFORNIA	1.075 (upside)	1.075	1.075	±2.50%	Market not included in CS model 5% to 10% increase in ridership
DEVELOPMENT IMPACTS (INCLUDING INDUCED COMMUTING)	1.1 (upside)	1.1	1.05	±10%	Lower impact in Valley to Valley Line as no direct service to either major city
TIME SENSITIVITY/ LONG ACCESS	0.95 (downside)	0.8	0.75 (downside)	±20%	Impacts flows with long access journeys or greater journey times than presented in SP; factor takes into account that many flows not significantly affected
CAR RENTAL	1 (neutral)	1	1	±10%	No impact on central forecast, but failure to model egress separately from access increases risk
INDUCED DEMAND	1.1 (upside)	1.1	1.1	±10%	Some HSR services have induced considerably more than this
COMBINED REVENUE FACTORS					
CENTRAL	1.36	1.15	1.03	±43%	
LOWER	0.78	0.65	0.58		
UPPER	1.95	1.64	1.47		

The Table 4 shows that our central forecast for Valley to Valley Line revenue (in current prices) is slightly higher than that of CS, with a range of c.±43% - i.e. a 90% confidence that revenue will be at least 58% of CS forecast and no more than 147% of CS forecast. These estimates are based on professional judgement and experience.

It is important to note that these estimates are based on the assumptions that were used by CS. If trains are faster or slower, more or less reliable, or priced lower or higher than assumed, the ridership and revenues will be different. Likewise the estimates are based on estimates of California population, employment and incomes, and assumptions as to the cost and characteristics of competing modes.

Victoria Taylor
Project Finance Advisory Limited
President and CEO

John Segal
First Class Partnerships Limited
Senior Associate

Disclaimer

Project Finance Advisory Limited ("PFAL") and its subconsultants have performed an independent review of the ridership and revenue for the Silicon Valley to Central Valley Line as directed by the California High-Speed Rail Authority ("Authority") and as described in PFAL's executed task order with the Authority dated June 16, 2016. This independent review was performed using documents and information provided by the Authority (listed in the body of this Memo) and developed using currently accepted professional practices and procedures. PFAL, at the Authority's direction, has relied upon the accuracy and completeness of the documents and information provided by the Authority. The accuracy and completeness of the documents and information provided by the Authority and other publicly available material reviewed by PFAL in connection with this Memo were not independently verified by PFAL, and PFAL does not assume responsibility for verifying such material. This Memo does not serve as an accounting audit. Furthermore, this Memo should not be relied upon for any financing or investment decision. It is possible that there are other elements of risk associated with the Authority's Ridership and Revenue Model beyond those presented. Any financial estimates, analyses or other conclusions in the Memo represent PFAL's professional opinion as to the general expectancy concerning events as of the evaluation date and are based solely upon the documents and information provided by the Authority. However, the accuracy of any estimate, analysis or other information set forth in the Memo is dependent upon the occurrence of future events, which cannot be assured. Additionally, these estimates and analyses rely upon the assumptions contained therein, the accuracy of which remains subject to validation, further refinement and the occurrence of uncertain future events. Estimates should not be construed as statements of fact. There may be differences between the projected and actual results because events and circumstances do not occur as expected.

The information and conclusions presented in this Memo should be considered as a whole. Selecting portions of any individual conclusion without considering the analysis set forth in the Memo as a whole may promote a misleading or incomplete view of the findings and methodologies used to obtain these findings.

APPENDIX A: STATEMENT OF FACTS

PFAL Project Finance Advisory Ltd.

August 11, 2016

Boris Lipkin
Deputy Director of Business Analytics and Commercial Implementation
California High Speed Rail Authority
700 L Street #1160
Sacramento, CA 95814

Re: HSR14-65 Task Order 2 Statement of Facts

Dear Mr. Lipkin,

Under Task Order 2 ("TO-2") of contract number HSR14-65, Project Finance Advisory Limited ("PFAL") and our sub consultant, First Class Partnerships Limited ("FCP"), conducted an initial review of the California High Speed Rail Authority's ("Authority") ridership and revenue projections as presented in the 2016 Business Plan. This work consisted of a review of (1) the publically available model and forecast documentation prepared by Cambridge Systematics, Inc. ("CS") on behalf of the Authority, (2) Ridership Technical Advisory Panel ("RTAP") reports and (3) information requested by PFAL from the Authority during TO-2.

To understand the assumptions and approach used to develop the ridership and revenue forecasts, PFAL and FCP requested clarification from the Authority through an Excel-based tracking matrix. The clarifications were categorized into nine topics: Source Data, Stated Preference Research, Buses, Market Segmentation, Induced Demand, Validation, Load Factors, Risk Analysis, and Other. The Authority and their advisors provided detailed responses to the initial clarifications and follow-on questions within the tracking matrix.

PFAL's future analysis will ultimately rely on the information provided in the tracking matrix, supplemental documents provided by the Authority during TO-2, and model and forecast reports available on the Authority's website. For the purposes of confirmation, we have summarized PFAL's and FCP's understanding of the Authority's detailed responses in the tracking matrix as it pertains to our review under TO-2.

1. Source data

    a. Long distance model data were obtained from 1,965 households of the 42,431 households responding to the daily diary portion of the 2012-2013 California Statewide Household Travel Survey ("CSHTS") as well as from 12,183 self-selected households responding to the Long-Distance Travel Recall Survey component of the survey. As would be expected in a survey of this nature, the CSHTS respondents were essentially self-selected. The 42,431 respondent households comprised approximately 2% of the households in the original random sample; the 12,183 households responding to the Long-Distance Travel Recall component comprised approximately 0.6% of the households in the original random sample.

    b. The CSHTS used a quota based random sampling methodology designed to minimize overall sampling bias. As a result of the quota based sampling, overall trip rates were derived from household data which had been scaled up to match statewide geographic and demographic distributions of total households. In addition, long-distance trip rates were adjusted based on data from the 2011 Harris survey performed for the Authority. These resulting long distance trips were validated with other sources, including data from the Federal Aviation Administration ("FAA"), and from Conventional Rail ("CVR") operators.

c. Long distance data (defined as trips 50 miles or greater) from the 2012-2013 California Statewide Household Travel Survey was validated with the following data sources:

   i. 1995 American Travel Survey ("ATS"), in which long-distance trips are defined as greater than 100 miles.

   ii. Version 1 Model (calibration year 2000).

   iii. 2001 National Household Travel Survey ("NHTS").

   iv. 2009 NHTS, which did not have a separate long-distance component.

   v. 2011 Harris Survey (long-distance trips only, interstate travel not included).

d. Total valid survey responses to the CSHTS relied upon for the model was 38,787

e. Of the long distance responses to the Long-Distance Travel Recall survey, 728 long distance trips were from Metropolitan Transportation Commission ("MTC") to San Joaquin Valley ("SJV") and 1,340 were from SJV to MTC.

f. Passenger Count air passenger data in Table 2-17 of the Business Plan Model – Version 3 Model Documentation ("BPM–v3") excludes interlining passengers.

2. Stated Preference Research

   a. The stated preference research examined the willingness of air, conventional rail, and auto travelers to switch to high-speed rail ("HSR"). Long distance bus service was not offered as an optional mode in the stated preference experiments.

   b. The stated preference research experiments told intercepted travelers on air and rail to assume the same access/egress mode and distance as their current trip for all experiments. The research did not vary access/egress assumptions for individual experiments. The stated preference research did not explicitly consider willingness of auto, CVR, and air travelers to switch to a thruway bus to HSR service as will be offered as an optional access/egress mode for some markets during the operation of the Valley to Valley Line. Respondents were told to assume the same access/egress modes that they used for air and CVR.

   c. Long access/egress by auto and transit was made less attractive by a variable adding extra generalized cost to trips that would have disproportionately long access or egress leg relative to the length of the whole trip.

   d. Income Alternative Specific Constant ("ASCs") were used in all model estimation runs; no estimations were run without testing the income ASCs for air, CVR, and HSR. The BPM-v3 includes positive income specific ASCs for high income travelers using air or HSR for business/commute trips and a positive ASC for low income travelers and a negative ASC for high income travelers on CVR for recreation/other trips.

3. Buses

   a. Bus data from 2012 CSHTS showed approximately a 1% market share state wide for long-distance trips and 800 daily bus trips in the Bay+Capital to Basin market. No additional bus ridership studies have been conducted since.

   b. BPM-v3 currently excludes main mode long distance bus trips, but considers bus service as an access/egress mode by transit (i.e. HSR bus is one of several transit modes considered as transit access/egress modes to HSR). The Authority does not view long distance bus service as a significant competitor to HSR. Long distance bus passengers were excluded from the model prior to estimation and calibration (i.e. existing long distance bus trips were assumed to continue to be made by bus and were excluded from the HSR model).

c. The impact of bus/rail transfers were effectively calibrated as an ASC in the access/egress mode choice model.

d. Model assumes a 15-minute transfer time from an HSR bus to the high-speed rail system which is similar to Amtrak schedule assumptions, and will ultimately be set by the operator. No reliability is specified in the model for buses since they are considered an access / egress mode.

e. Northern California HSR bus trip times were based off Google Maps assuming light traffic and approximately 10 additional minutes' travel time built in at each stop. Southern California HSR buses were based on existing Amtrak bus schedules with some additional time built in. If Amtrak bus schedules were not available, Google Maps was used for trip times, but assuming heavy traffic and an additional ~10 minutes built in at each stop.

f. Approximately 400,000 of Amtrak San Joaquin's 1.2 million riders in 2014 used Thruway buses from Bakersfield – Southern California, and 400,000 used Thruway bus connections at Emeryville, Stockton, Hanford and Merced. The use of Amtrak San Joaquin Thruway buses provides empirical evidence supporting BPM-v3's HSR feeder bus ridership forecasts. In the Valley to Valley ("V2V") scenario, the BPM-v3 model predicts 3% of all HSR riders use feeder buses to/from Fresno and 8% use feeder buses to/from North of Bakersfield. In the V2V Extended scenario, 2% of all HSR riders use feeder buses to/from Fresno and 5% use feeder buses to/from Bakersfield. Feeder buses do not represent the only access/egress modes available at those stations.

g. HSR bus revenue and ancillary revenue are not included in Exhibit 6.3 or any revenue forecasts in the 2016 Business Plan except for the Net Cash Flow from Operations exhibits.

h. Long distance bus trips reported in the CSHTS was 275. Of the 275, 202 responses were for interregional bus trips. Actual observations of bus trips by travelers in the corridor to be served by HSR are listed in the following table:

Observations of Bus Trips and Expanded Daily Bus Person Trips					
	MTC SJV	SCAG SJV	SJV SJV	MTC SCAG	**Total**
Observations	11	34	10	16	**71**
Expanded PT	139	1,140	183	365	**1,827**

4. Market Segmentation

a. Single average fare assumed in model for each station-to-station pair, both for estimating coefficients and when making forecasts. Authority is using average fare at this time with the expectation fares will be optimized in the future when an operator is hired. Sensitivities around varying fares for business vs leisure passengers will be conducted by the Authority or the operator, as necessary, at a time closer to operations.

b. Log-arc HSR fare elasticities to ridership (not to revenue) estimated from BPM-v3 model sensitivity testing:

Fare Change	Elasticity to Fare		
	B/C	R/O	**Overall**
-50%	-0.50	-0.63	**-0.58**
+50%	-0.90	-1.07	**-1.01**

c. Sensitivities for lower fares: overall sensitivity was tested, but fares were not optimized

d. The same fares were assumed for HSR in all the phases

e. Current fares assumed are generally based on boarding and distance-based fare components, and are subject to change depending on the operator's fare policy

f. Blended average air fare was assumed for each airport to airport interchange based on data from the BTS.

g. Actual fare data for air, bus and conventional rail was not collected in recall survey

5. Mode constants

   a. The mode constant for air vs auto vs conventional rail is calibrated to existing mode shares. Mode constant for HSR is derived from the SP research combined with the results from the calibrated Air and CVR mode constants. Two different approaches were identified as reasonable, and the central forecast is based on the average of these. They do show that HSR is significantly preferred to CVR all other elements equal, but in part this is because of factors not included within the generalized cost. Explicitly modeled level-of-service variables for the main mode include travel time, travel cost, frequency of service, and reliability of service.

6. Induced Demand

   a. The long distance model includes both destination choice and trip frequency.

   b. The model does not include any impact of HSR on development around stations served unless it was included in statewide or MPO socioeconomic projections, produced independent of the Authority.

   c. Benchmark research, such as Acela induced demand, was determined not to apply to the California market.

   d. .

7. Validation

   a. CHSRA provided assumed rates for parking charges at HSR stations, ranging from $14 to $44 per day, and that parking is available to meet demand at all times at or around stations. No estimates have been made in the model of the number of spaces that will actually need to be provided at each station or on the entire system.

   b. A substantial difference found between the 2000 backcast of air and actual was addressed in February 8, 2016 Response to December 16, 2016 Technical Memorandum – Review of Progress on Ridership and Revenue Forecasting memo. The memo outlines potential reasons for difference and analysis performed to update Year 2000 backcast for the BPM-V3 documentation.

c. The Value of Time ("VoT") is derived from the estimated coefficients of travel time and travel cost. It varies by purpose and income group but is constant across the state.

d. In the V2V – Extended scenario, the model forecasts some traffic from SACOG to MTC, apparently via San Francisco and then on HSR to Millbrae, San Jose and Gilroy.

8. Load Factors

   a. Model is daily and summarized in annual trips; distribution of demand through the year and across the day has not been forecasted.

   b. Average load factor analysis has been conducted to ensure that service will accommodate ridership projections.

9. Risk Analysis

   a. The risk analysis covers both external factors and internal factors that will be under the control of the HSR operator or the Authority but where decisions have not been made at this time.

   b. Frequency distributions are based on daily peak and off-peak roundtrips rather than a specific service plan that will be determined by the operator at a later date.

   c. The majority of the risk is associated with the mode constants ("ASC") for HSR in part due to the large range selected for HSR by setting the lower bound at the level of CVR.

10. Other

   a. Non-residents (of California) have been excluded from the potential rider pool and this represents a conservative assumption. The Authority is currently reviewing potential non-resident ridership for inclusion in future models.